SCIENTIFIC AMERICAN SUPPLEMENT, No. 1060

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Scientific American Supplement, Vol. XLI. No. 1060.
Scientific American, established 1845.

NEW YORK, APRIL 25, 1896.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE MOVING OF HEAVY BODIES IN ANTIQUITY.

ARCHITECTS are not ignorant of the fact that ancient peoples in the construction of their buildings employed stones that were much larger than those used to-day. All those who travel through ancient regions look with astonishment and admiration at these gigantic structures whose walls, lintels, columns and entablatures are formed of materials of extraordinary dimensions. How did the ancient builders manage to carry and put in place so huge blocks of stone? We possess no works capable of informing us as to the processes of construction of that epoch, and it is necessary to have recourse to the sparse information furnished us by history, ruins, mural paintings and sculptures. Such testimony has been collected and presented in the Engineering Magazine in a very suggestive manner by Mr. W. F. Durfree, an American civil engineer.

I.—THE LIFTING AND CARRIAGE OF HEAVY BODIES.

Going back to primitive times, the author teaches us that, in order to lift and carry large masses, direct use was made of the muscular power of a sufficient number of men to produce the desired effect without the intervention of machines or apparatus. The heavy pieces of framework and the planks employed in the construction of vessels were carried up inclined planes, as shown in Fig. 1, which represents a number of laborers bearing a beam upon their shoulders.

It was difficult to make certain that each man carried his share of the burden properly, since the irregularity of the ground alone prevented an equal distribution of the load. Certain masses possessed such a form that it was impossible to obtain a good hold of them, although the weight was not excessive.

All such inconveniences were avoided by the Chinese, who still utilize these primitive methods. In fact, the artillery buildings at Hong-Kong were wholly constructed by Chinese laborers under the direction of Maj. Edward Aldrich, R.E., who found that these men were ignorant of the science of mechanics and were little disposed to make use of it. Four hundred and sixty-two granite columns, each weighing 4,300 pounds, were carried from the quarries to the scene of operations 2,600 feet distant, by 36 men, arranged as shown in Fig. 2. Fig. 3 shows the arrangement of the building timber and of the bamboos, from which the column was suspended by means of lashings and of rods serving as balancing poles. The junction of the different parts of this very simple and very ingenious mechanism was such that each man placed at the extremity of a bamboo had to support an equal portion of the load. None of them could complain of his part of the work, considering in what it consisted, nor execrate the irregularities of the road to be traveled.

In order to effect the carriage of one of these columns, the men walked in step, changed their pace from time to time and at the same moment shifted the load from one shoulder to the other.

The drag appears to have been the favorite vehicle of the ancient Egyptians and Assyrians for the carriage of heavy loads. We do not believe that wagons were known in the primitive times of these countries, although mural paintings and sculptures show us carts and chariots, the latter rather constituting apparatus of military equipment. According to Diodorus Siculus, Sesostris (2600 B. C.) had 27,000 chariots, and Joshua (1450 B. C.) teaches us that the Canaanites possessed iron chariots. Salom (1000 B. C.) obtained a chariot from Egypt at a cost of 600 shekels of silver (about $160) that served as a model for the 114 chariots placed in the fortified city of Judea. However, although the Egyptians and Assyrians were already familiar with the use of wheeled vehicles, we do not think that they employed them for the carriage of building materials. The drag alone was used for such a purpose, and this was sometimes drawn by oxen and often by a large number of men.

A painting found at El-Mausara represents a drag (a trace of which we find to-day in the stone boat) loaded with hewn stone and drawn by six oxen (Fig. 4). Funeral barges were carried upon drags in Egypt (Fig. 5). A colossus was carried from a tomb situated at El-Bersheh upon a drag drawn by men.

FIG. 1.—BUILDING TIMBER CARRIED UPON THE SHOULDERS.

FIG. 2.—CHINESE METHOD OF CARRYING A COLUMN.

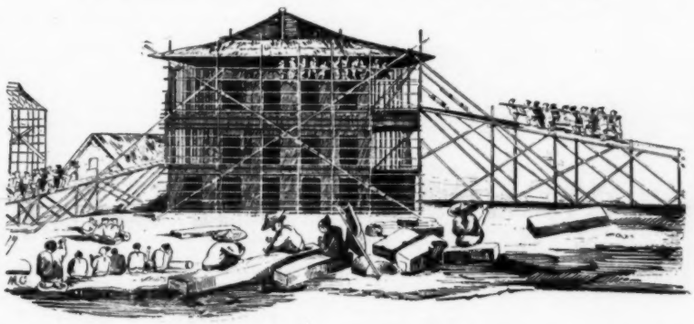


FIG. 3.—CHINESE METHOD OF CARRYING LOADS UP AN INCLINED PLANE.

The ancient Assyrians seem to have copied after the Egyptians in the use of the drag. Two sculptures discovered at Nineveh by Layard show the operation of carrying a bull having a human head. Rollers were employed under this drag, and the use of a lubricant therefore became unnecessary. This also dispensed with the presence of a man constantly occupied in oiling, as the practice was in Egypt. In order to set the drags in motion and ease the posterior extremities in case of depressions in the road, large levers were employed. Capstans, ropes, rollers and levers were provided in abundance. Some men were occupied in throwing aside the stones and other objects from the route that the drag was to follow.

The Egyptians excelled all the other people of antiquity in the art of getting out large blocks of stones and carrying them to great distances. In the plain of Quorreh there are two colossal monolithic statues of the time of Amenophis III (about 1400 B.C.), one of which, representing the musician Memnon, is 57 feet in height and weighs about 100 tons. Herodotus relates that 2,000 men were occupied for three years in carrying from Elephantine to Sais, at the order of Amasis (569 to 565 B.C.), a block of stone that was to be used as a small temple or sanctuary. This block measured 31¼ × 22 × 12 feet, externally, and 28¼ × 18 × 7½ internally. Its weight was about 400 tons.

The carriage of great masses by water was frequently practiced in the two Assyrias and Egypt. A

FIG. 4.- ANCIENT USE OF THE DRAG.

FIG. 5.—EGYPTIAN FUNERAL BARGE CARRIED UPON A DRAG.

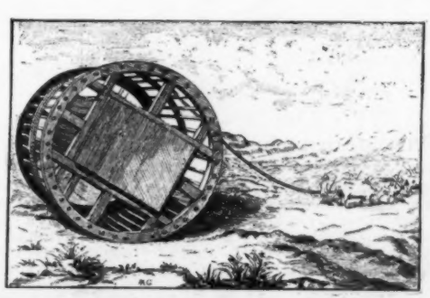


FIG. 6.—PACONIUS' METHOD OF CARRYING THE BASE OF A COLOSSAL STATUE OF APOLLO.

bass relief of Koyunjick (2000 B. C.) represents stones carried by means of a train of wood supported by inflated bladders. It is absolutely certain that the limestone used in the pyramids of Gizeh (3200 to 900 B. C.) were carried in part by water, since the quarries whence it came were situated to the east of the Nile.

Pliny says that the obelisks were carried by river upon two flat bottomed boats connected side by side, and introduced into a basin excavated at right angles upon the edge of the river, under the obelisk. These boats were previously ballasted with a weight of sand equal to that of the block to be carried. Then, when they were well in place, the sand was removed, the boats arose and the obelisk took the place of the sand. Pliny attributes the invention of this process to a Phenician, but gives no date.

The invention of certain very ingenious processes for the carriage of columns in the rough and large rectangular blocks is also attributed to the architects and engineers of Asia Minor. Chersiphron, the architect of the great temple of Diana at Ephesus (600 to 500 B. C.), one of the seven wonders of the world, executed the designs for 127 columns of white marble 60 feet in height and 7 in diameter.

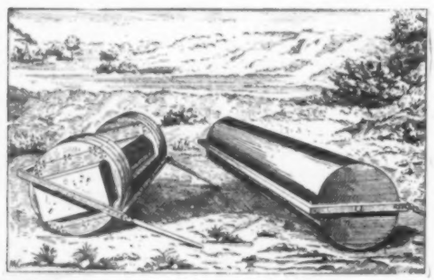


FIG. 7.—CHERSIPHRON'S METHOD OF CARRYING THE COLUMNS OF THE TEMPLE OF DIANA.

Metagenes' modification of the process (to the left).

According to Vitruvius, this architect, finding that the roads were not firm enough to support the weight of such columns upon vehicles, as the wheels would easily penetrate the earth, invented a frame consisting of four planks inclosing the column, which was simply rough hewn. To the center of each extremity he fixed a large bolt sealed in the stone with lead and the projecting part of which passed into iron bearings that were held in wooden crosspieces. Oaken rods to which were fixed iron hooks and rings permitted of the harnessing of oxen to the whole. The animals in walking caused the revolution of the column, which was thus drawn, not without great difficulty, to Ephesus, that is to say, to a distance of 8 miles.

Pursuing the idea of Chersiphron, his son Metagenes, who succeeded him as architect of the temple, invented a process for the carriage of the architraves, some of which were 30 feet in length. He constructed large and strong wheels, 12 feet in diameter, between which he attached the architrave, provided with large bolts placed at the extremities and entering the bearings of the crosspieces of the frame, as with the columns. Oxen harnessed by means of hooks drew the stone, as we have said above (Fig. 7.)

In the time of Vitruvius (about 30 years B. C.) a certain Paconius undertook to carry from the quarry the base, 12 feet in height, 8 in width, and 6 in length, of a colossal statue of Apollo.

The machine, although similar to that of Metagenes, differed slightly therefrom in the details of construction. It consisted of two strong wheels, 13 feet in diameter, fixed to the extremities of the stone. These two wheels were connected by spindles, around which wound a cable to which the oxen were attached.

Vitruvius tells us that, as the cable never drew

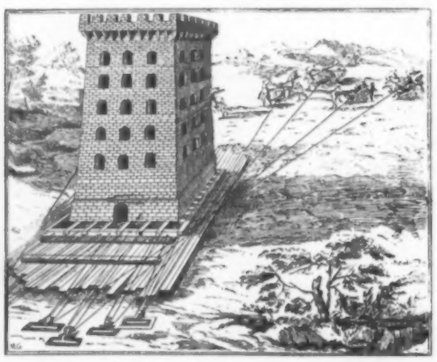


FIG. 8.—MOVING OF A MASONRY TOWER BY AN ARCHITECT OF BOLOGNA (FIFTEENTH CENTURY).

from a fixed central point, the apparatus went continually from the right to the left, and vice versa, and did not fulfill the end intended. M. Perrault is surprised that the idea did not occur to Paconius to add a second cable, which would have rendered the traction uniform.

Among the processes employed by ancient engineers for moving large masses, we may mention the method of displacement of wooden towers used in the attack of fortified places.

These towers were called "heleopoles" (from ἕλειν, "to take," and πόλις, "city"). The Greeks attributed the invention of them to Demetrius Poliorcetes, who utilized them at the siege of Rhodes (305 B. C). Once filled with armed men, the tower was drawn toward the point selected for the attack. The men who maneuvered the cables were protected by the tower itself. As soon as the latter reached a point near enough to the invested place, two drawbridges were lowered upon the wall of the city and a portion of the men making the assault rushed upon these bridges and took possession of the position nearest the point of attack. Reinforcements were sent upon the bridge, and, during this time, the defenders of the place were assailed with arrows, stones and other missiles thrown from the summit of the tower, which was always high enough to command the point attacked. Some of these towers were a hundred feet in height. Anne Commene (born in 1803) thus describes, in her Alexiad, a tower employed at the siege of Duvas: "It was square and of such a height that it surpassed all the towers of the city. It was decided to descend upon the walls of the city by means of bridges and to fall with irresistible impetuosity upon those who defended it. It was a fearful spectacle to behold, even from a distance. The tower advanced like a giant with rapid strides that nothing could resist. It was provided with numerous apertures through which the men fired without cease. The upper story was filled with warriors, arms in hand, whose attack was continuous."

The carriage of the obelisk of Seringapatam (toward 1815) from the quarry to its proposed site, at a distance of two miles, was effected by native laborers of India, without the aid of any European. The following is a description of it as given by Col. Wilkes: "The vehicle upon which the shaft of the obelisk was carried from the quarry was supported by eight wheels or rollers, four of which were placed externally and four internally. It required about 600 men to draw the obelisk, and the operation was very fatiguing."

Fig. 8 gives an idea of the method of moving a masonry tower employed by an architect of Bologna in the fifteenth century. The operation was analogous to that of the moving of the heleopole of Demetrius, but in this case large rollers, instead of wheels, were employed.

II.—REMOVAL OF HEAVY BODIES AND PUTTING THEM IN PLACE.

The value of the inclined plane as a means of raising

FIG. 10.—USE OF A CRANE FOR ATTACKING A TOWER.

heavy objects to great heights was recognized by man at an early period.

As a preliminary to the construction of the great pyramid, the engineers of Kufu (Cheops, 3050 B. C.) constructed an inclined plane of masonry in order to raise the stones from the level of the river to that of the platform upon which the pyramid was to rest. The height was 164 feet above the mean level of the lowest water of the Nile. This sloping causeway was 3,000 feet in length and 60 in width. On the east side it was contiguous to a canal that communicated with the Nile. It was by this route that it was possible, through boats, to bring the stones from the quarry and deliver them promptly at the foot of this vast incline, up which they were doubtless drawn by means of drags moved by men or animals.

In quarries, etc., processes were formerly employed that our modern workmen have integrally preserved for raising and turning over stones. Thus, a hewn stone was raised by inclining it and placing blocks of wood under each of its faces alternately. This method was not used for lifting stones to a great height, but simply for moving them to a distance of a few feet. It necessitated an insignificant amount of manual labor. A very ancient method of turning over a stone consisted in placing a piece of wood under it so as to make it tilt in such a way that it required but a small amount of force to handle it. In cases where it was desired to turn a stone end for end, another process just as old was employed. The rotation was effected upon a block of wood whose under surface was rough hewn and which acted as a pivot.

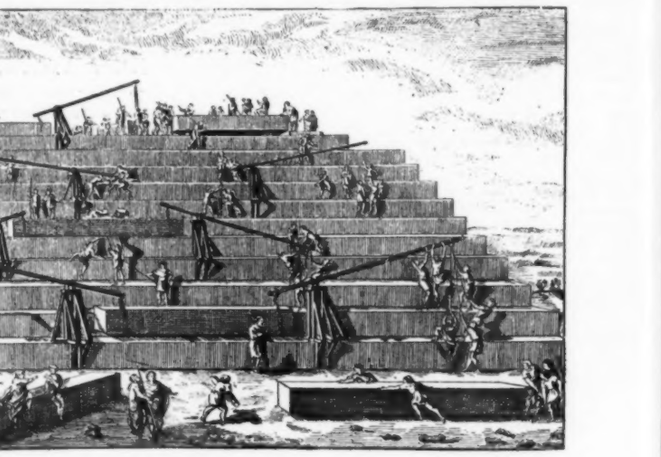


FIG. 9.—APPLICATION OF THE PROCESS OF LIFTING MATERIALS DESCRIBED BY HERODOTUS.

We do not know for certain the methods employed by the builders of the great pyramid for putting the stones of the latter in place, but it is probable that the methods described above were put to profit. Herodotus tells us that after the stones of the base had been laid the others were raised to their place by means of machines formed of short wooden planks. One machine raised them from the ground up to the level of the first course, and upon the latter another machine received the stone and carried it to the second course, while a third machine raised it still higher. From Herodotus' description, a practical machine for the carriage of stones has been deduced by De Goguet. Fig. 9 seems to us sufficiently clear to allow us to dispense with a fuller explanation. The idea of a "compound lever" with a swinging motion was inspired by the ancient Egyptians, the inventors of the "shadoof." This machine, which is found upon the banks of the Nile, from its delta as far as to Ethiopia, was used by the ancients for raising water. Layard found traces of it in a bass relief of the mines of Nineveh. In Persia and other parts of Asia, the shadoof was in common use. In this apparatus, we find the first application of one of the simplest of mechanisms for raising bulky materials and putting them in place. These kinds of apparatus are at present grouped under the generic name of "cranes."

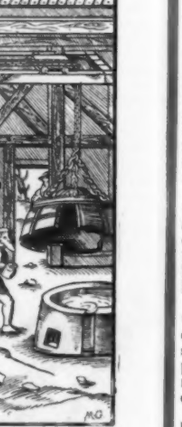


FIG. 11.—ANCIENT FOUNDRY CRANES.

The crane consisting of a rocking lever was used in ancient military operations either for attack, as shown in Fig. 10, or for defense. Such apparatus were employed by Archimedes for the destruction of the vessels of Marcellus at the siege of Syracuse (214–213 B. C.) In 1676 the Italians made use of long levers

suspended by a short chain provided with hooks for the unloading of boats.

Wilkinson states that the ancient Egyptians were not unacquainted with the pulley. One of these apparatus, recently discovered, has been deposited in the museum of Leyden.

In his description of the construction of the obelisk of Seringapatam, Dr. Kennedy states that it was raised by laborers who aided each other with crowbars bearing upon planks parallel with the obelisk, and who rammed down the earth solidly in measure as the shaft arose. This method doubtless offered the maximum of security. It is probable that the Egyptian method did not offer as much security as that of the Indians, for Pliny states that Rameeses (1250 B. C.) had an obelisk 99 × 8 feet constructed, upon which he employed 20,000 men, and fearing that the engineers might not take sufficient precaution, seeing the feeble power of the machine as compared with the weight to be raised, had his own son attached to the top of the obelisk in order to more efficaciously guarantee the preservation of the work.

The idea of a crane with a vertical post and a horizontal jib was doubtless suggested by the arrangement of the trunk and branches of a tree. Fig. 11 represents one of these cranes utilized in foundries in the middle of the sixteenth century. A crank acts through the intermedium of several gear wheels upon a chain winding around a drum. We remark here the evidences of a carriage rolling along the jib of the crane, but it is impossible to see by what means it could have been set in motion.

Other cranes were constructed at about the same epoch for the handling of stones. They were provided with a double rotary and horizontal motion. We still meet with cranes of this kind in factories and quarries, upon river wharfs and in seaports. They are much less clumsy, however, and as soon as they reach a high power they are actuated by means of steam or electric motors, and it is possible for a boy to aid in the loading and unloading of several tons of material without effort.

Along with the crane, properly so called, we must mention the shears, a machine much used in artillery for lifting large guns and placing them upon their carriages, and in places where building is going on for raising materials of construction. It does not suppose a knowledge of gear wheels, for here it is the pulley that plays the most important role. This pulley is placed at the summit of a frame formed of three spars, two of which are connected at the bottom by a crosspiece and at the top by an iron bolt. A rope wound around the pulley supports the weight to be lifted at one of its extremities and at the other end passes over a windlass that is maneuvered by means of levers. The third spar is movable and permits of assuring the stability of the apparatus. In most cases this spar is replaced in constructions by a guy rope whose free extremity is attached to a tree or house or any other firmly established object.

Finally, when it is desired to raise a heavy weight, it is preferred in constructions to use the derrick, which consists of a vertical mast and a windlass. The mast, which is held in position by strong guys, is provided at the top with an arm carrying tackle at its extremities. These, however, are recent apparatus that do not exactly come within the scope of our article.—Le Monde Moderne.

SINGLE DRIVER LOCOMOTIVES.

WE illustrate in this issue a very interesting locomotive, which has been recently built at the Baldwin Locomotive Works for the Philadelphia and Reading Railroad. The novel appearance of the engine is due to the absence of the trailing pair of driving wheels and the usual coupling rods.

This is not the first appearance of single drivers in the States; a few of this type having been built and put in active service in the pioneer days of railroading. But, for various reasons, they met with little favor, and quickly fell into disuse.

For hauling fast trains that make long journeys with few stops, the single driver has long been a favorite in England, where they have given great satisfaction. That they have not hitherto been built for American service may, no doubt, largely be accounted for by the fact that to gain the necessary adhesion with one pair of wheels it is necessary to put a very heavy load upon them—much heavier than the light rails, which were used on our roads up to a few years ago, could safely carry. Other things being equal, it is the cylinder capacity of a locomotive which determines its power; but the size of cylinders themselves must be governed by the adhesive power of the driving wheels.

As the cylinder power of the American locomotive increased, the designers preferred to couple on an extra pair of wheels, rather than increase the load on those already in use; and hence we find a good many roads that are using six coupled drivers on the locomotives that are built for hauling heavy trains at high speed.

Of late years, however, American track has been vastly improved, and it is safe to say that some of the Eastern roads possess a roadbed that is not surpassed by any in the world. The 90 pound and 100 pound steel rails now in use will carry with safety the maximum loads that could be put on locomotive drivers.

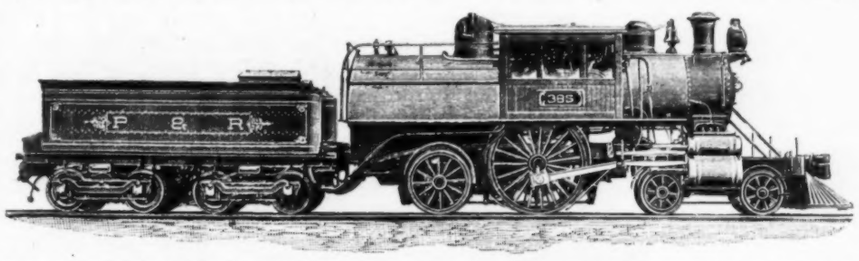
The new Philadelphia and Reading engine has no less than 24 tons load on its single pair of driving wheels, which are 7 feet in diameter. The two high pressure cylinders are 13 inches in diameter, and the two low pressure are 22 inches; the stroke being 26 inches and the steam pressure 200 pounds. It is said to be giving very satisfactory service.

One of the chief advantages of the single driver system is that it contributes to smoothness of running. By dispensing with the outside coupling rods the difficulties of counterbalancing are very considerably reduced. The counterbalance excess is comparatively small; and the destructive hammering action upon the rails resulting from this excess is brought down to a minimum. Coupling rods have long been regarded as a necessary evil. For many years they were continually giving way under the severe bending strains to which they were subject. The tee sections that have been very generally adopted of late years have met this difficulty, it is true; but the counterbalancing problem still exists.

If there should be any variation in the wear of the coupled wheels, so that their diameters do not agree, there will be a serious amount of friction set up; for, being coupled, the smaller wheel will drag upon the larger, or vice versa. In the single driver there will be some economy in maintenance resulting from the reduced number of wearing surfaces, this being reduced by the amount of four coupling rod ends.

It is not contended that the four coupled and six coupled express locomotive will be supplanted by the single driver. For hauling heavy trains at high speed, that make frequent stops, these engines are admirably adapted.

On the other hand, for hauling the fastest long distance expresses that make few stops, we think it quite possible that the new type will be found in every way more economical and effective.



EIGHT WHEELED LOCOMOTIVE FOR THE PHILADELPHIA AND READING RAILROAD.

A CURIOUS OLD STEAM ENGINE.

WE have spoken and written, says the London Engineer, with a feeling of no little admiration upon the subject of the machine tools made and used so effectively in Watt's day, and we now have the pleasure to place before our readers a freehand sketch of a type of engine which very few of the present generation can have seen. It seems to have been designed by the late James Watt during the lifetime of his father, and is probably 75 years old, and having regard to the celebrated tools which, through the courtesy of Mr. H. Darlington, the manager for the firm, we have from time to time been enabled to describe, we gladly couple with them the satisfactory performances of this engine, from which some of the principal tools derive their motion, and which appears to be as capable of discharging its duty in the future as in the past.

The peculiarity of its design caused it to be known as the "bell crank" engine. In all probability the dual work with which it was called upon to deal was the necessity which brought forth its general arrangement, adapted, as will be seen, both for pumping and tool driving.

With regard to the former capacity, our general view will show the lower arms of the bell crank levers coupled by a cross bar, from the center of which the main connecting rod transmits motion to the main crank, and thence by another rod to a second bell crank lever, which works a lift pump in a well.

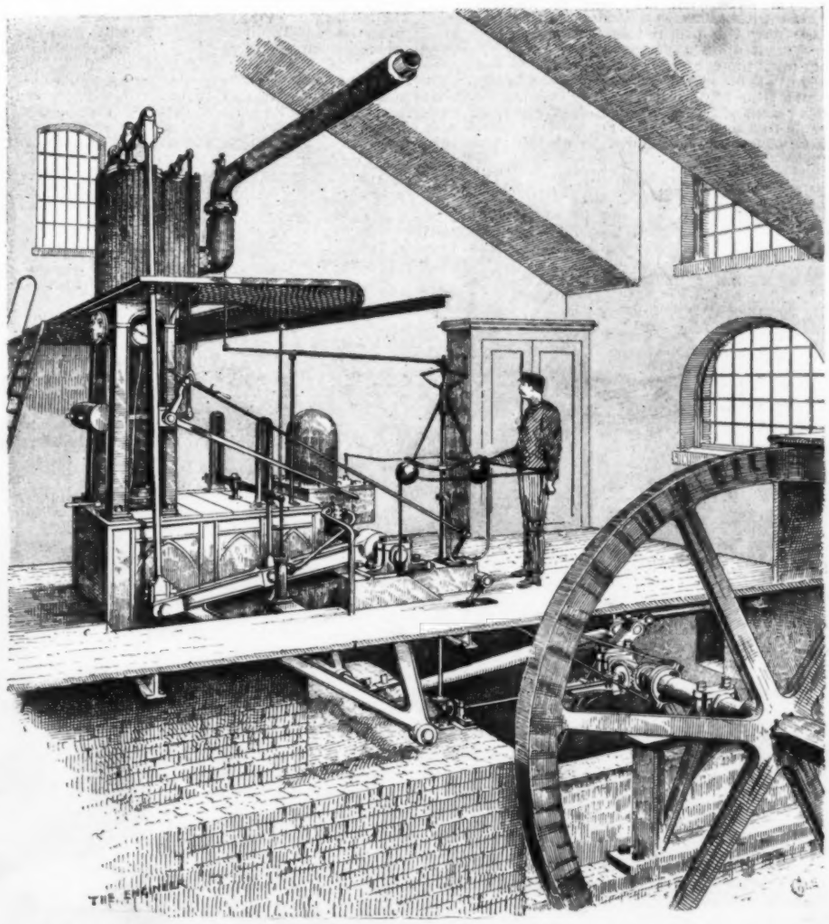
The duty of this pump was to lift water from a cooling pond situated in some gardens outside the works into an upper culvert and reservoirs in the yard for condensing and other purposes. For works driving it appears to have been used for several important tools; its main shaft being below the ground level was in position for driving the famous vertical boring bar, illustrated in our issue of September 27, 1895, which, it will be seen, receives its motion from below the saddle plate.

Large lathes also and machine tools in the screwing shops were driven by this engine, among the latter being a heavily geared tapping machine. Messrs. James Watt & Company were no believers in thread cutting otherwise than by tapping, as is universally done in dealing with small sizes; but here were to be seen ponderous tools for the production of nuts to fit threads of 5 in. diameter, the taps being as long as 2 ft. 6 in.

We are informed that the vacuum of this engine was so good that it could boast of enough and to spare, and that a 6 in. pipe was connected with the condenser of a 24 horse power beam engine in an adjacent building for the purpose of reducing the inefficiency of the latter. In all other respects, we understand its character has universally been that it was ready for work night and day for weeks together. This ever ready quality was a necessity, because the engine drove the boring bar which could boast of such capacities as those mentioned in our description of this particular tool. Its working pressure was that usually adopted in those far off days, viz., 10 lb. The main shaft, which is square, is below the ground level, and is carried upon pedestals supported upon brick piers, and the rocking shaft upon which the bell crank levers are keyed has its bearings just above the ground level.

The air pump is worked from the horizontal arms of the side levers, and the eccentric rod is thrown out of gear by means of the disengaging apparatus, so much used in those days, which acts in opposition to the gravity of the rod.

Diameter of cylinder = 18 in.; stroke = 26 in.
Diameter of air pump = 15 in.; stroke = 11 in.
Diameter of well pump = 10½ in.; stroke = 19 in.
Diameter of fly wheel = 11 ft. 6 in.



A CURIOUS OLD WATT ENGINE, SOHO FOUNDRY, ENGLAND.

The well pump is about 43 ft. from the main shaft, and its lift is about 15 ft., the stroke of 19 in. being due to unequal leverage of its bell crank arms. The slide valve is worked from the top of the steam chest by side rods connected with levers on a rocking shaft off the main frame, and the engine is controlled by the old type of fly ball governor—one of Watt's minor yet most essential inventions.

In concluding our several notices of these far-famed works, almost coincident with the hundredth anniversary of the memorable inauguration of 1796, we do so with feelings of regret that the works have not been more successful, and it only remains for us to chronicle the fact that in making a large radial suction pipe, 24 in. diameter, for the Warsaw Waterworks, the famous firm of James Watt & Company, of Soho Foundry, Smethwick, poured their last ladle of metal at 4:50 P. M. on Wednesday, September 18, 1895.

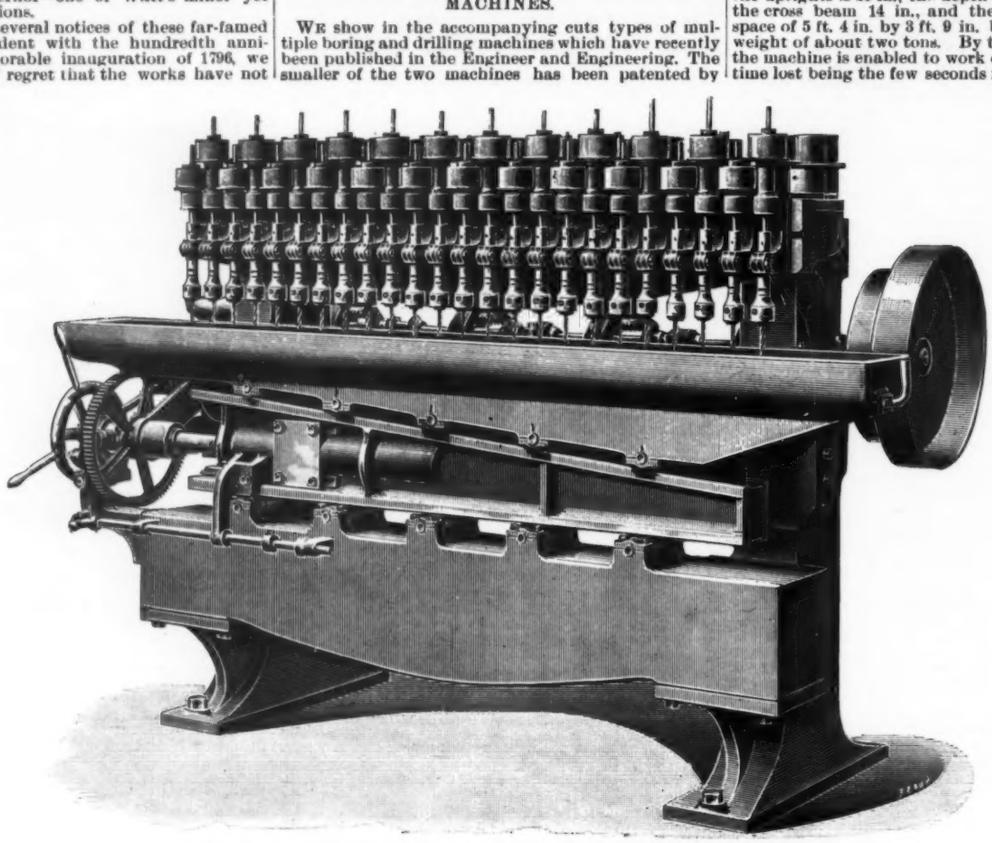
We add with pleasure that Messrs. W. & T. Avery, who are now the proprietors, having purchased the establishment upon a valuation, as a going concern—but not until the contents of the mint had been scattered—have decided to carry on the works under the style and title of James Watt & Company, without removing some of the machine tools of which we have been able to speak so highly.

Messrs. Avery have decided to abstain from dismantling this substantial and well-tested collection of machinery. They have plenty of room for new tools, and some of the old will be useful for almost any heavy work.

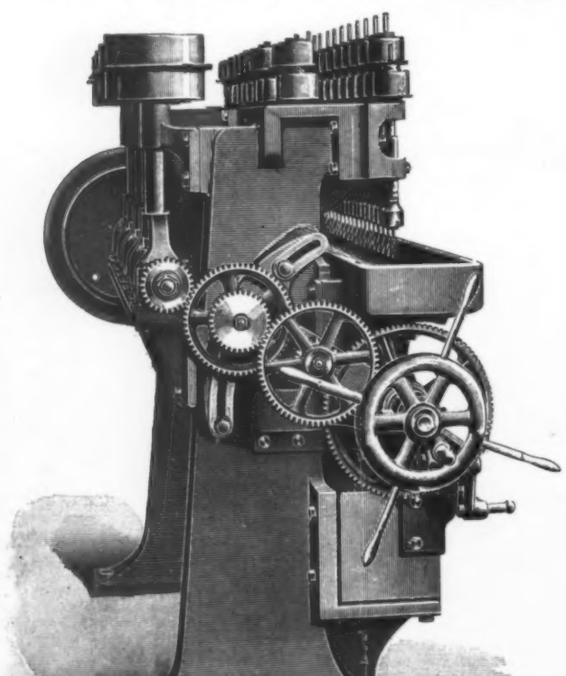
MULTIPLE BORING AND DRILLING MACHINES.

WE show in the accompanying cuts types of multiple boring and drilling machines which have recently been published in the Engineer and Engineering. The smaller of the two machines has been patented by Messrs. Cunliffe & Croom, of the Broughton Iron Works, Manchester. The main object for which the machine has been constructed is for boring and reamering two pulleys at one operation, and it consists of a circular table 36 in. diameter, provided with bolt grooves, for securing the fixings to it, and accurately divided into five divisions, so that, when the table is rotated and the stop peg pressed home into the conical steel bush, the boring tool and reamer are in their exact positions for operating in a combined manner upon the work to be done, the boring tool to bore the pulley and the reamer to finish it. When the drill headstock is in its highest position of adjustment, objects 12 in. deep can be rotated on the table, allowing for thickness of cramps, and a twist drill 1¼ in. diameter and of the standard length. The extent of self-acting down feed is adjustable to a maximum of 10 in., and the headstock can be adjusted vertically to compensate for the shortening by wear and tear of twist drills, etc., and still give the same amount of down feed and clearance under the drills. The space between the uprights is 20 in., the depth between the table and the cross beam 14 in., and the machine occupies a space of 5 ft. 4 in. by 3 ft. 9 in. by 6 ft. 7 in., with a weight of about two tons. By the above arrangement the machine is enabled to work continuously, the only time lost being the few seconds required to rotate the table to the next division. The machine illustrated, as already stated, has been designed for two spindles. The number of spindles can, however, be increased to three, four, five or six, according to the space occupied by the article to be operated upon.

In the other illustrations is shown a multiple drilling machine, carrying twenty-four spindles, and specially designed by its maker, Mr. Alfred Herbert,



TWENTY-FOUR SPINDLE MULTIPLE DRILLING MACHINE.



TWENTY-FOUR SPINDLE MULTIPLE DRILLING MACHINE.

MULTIPLE BORING AND DRILLING MACHINE.

Limited, Coventry, for drilling the holes in the finger bars and knife bars of reaping and mowing machines. The conditions to be met comprise the simultaneous drilling of twenty-four holes of from ¼ in. to ⅞ in. diameter, at a nominal pitch of 3 in., but this pitch has to be capable of slight adjustment. As constructed each spindle is carried in a separate head, which is bolted by means of a T slot to the cross bar of the machine, and so arranged that a slight side adjustment can be given to each head. At the same time each spindle can also be adjusted vertically, so that it is not necessary to use drilling bits of equal length in all the sockets. This is accomplished by placing the lower sleeve in which each spindle runs in a split socket, to which it can be clamped by tightening up the bolts clearly visible in Fig. 1. The driving pulleys are mounted on a second fixed sleeve running in bearings at the top of the spindle brackets. The spindles pass through these sleeves, to which, however, they are connected by a loosely fitting key. The end thrusts of the drills are taken on ball collars of hardened steel. The driving pulleys are staggered, as will be seen on reference to Fig. 1. This arrangement admits of the spindles being pushed close, without necessitating the use of very small driving pulleys. The machine is driven from a horizontal shaft at the back (see Fig. 2), at one end of which a cone pulley is fitted, giving two changes of speed. On this horizontal shaft are four pairs of machine cut bevel gears, driving four short vertical shafts. On the upper end of each vertical shaft is fitted a wide drum, divided in its center by a flange. A group of three of the upper row of driving pulleys is driven by an endless belt, running over adjustable idlers from the upper portion of the drum on the upright shaft, while a group of three of the lower row of pulleys is driven in a similar manner from the lower portion of this drum. The adjustable idler pulleys admit of the belts being tightened up, and it will be seen that the only gearing in the driving motion consists of the four pairs of bevel wheels, which, however, run at a comparatively low speed, so that the vibration and noise of high speed gear are avoided. The feed motion is effected by raising the table by means of a long wedge, which bears on steel rollers. This arrangement supports the table practically throughout its whole length, and avoids any sagging. The wedge is fed forward by means of a screw and train of change wheels, so that any desired rate of feed can be obtained. The feed motion is thrown off automatically at any desired point by a clutch, and there is a quick return for lowering the table. The work is submerged in suds during drilling, so that the trouble of lubricating the twenty-four spindles by means of separate dripping pipes is avoided, and a thoroughly efficient lubrication is obtained. The weight of the machine is 2 tons 15 cwt.

THE FLIGHT OF A MODERN PROJECTILE.

ON the walls of Dover Castle the visitor is shown an ancient gun of unusual size, which for several centuries has pointed its muzzle at the opposite cliffs of France, distant some twenty miles. Cut into the metal in rude letters is the following inscription:

"Sponge me well and keep me clean;
I'll throw a shot to Calais Green."

As Calais is some 21 miles distant from the castle, it is safe to say that the burghers and their families were left in undisturbed possession of "The Green." If this medieval relic was ever fired, the passing ships had only to keep a mile or so clear of the castle to be safely beyond its range.

Not so, however, with modern ordnance. There are guns in existence which, if they could not throw shells from Dover to Calais, could certainly drop them into the sea in dangerous proximity.

The extraordinary velocities which have lately been obtained from experimental guns 50 to 60 calibers in length make a range of 21 miles a possibility of the near future; though we are not aware that such a range has been achieved or authentically made public.

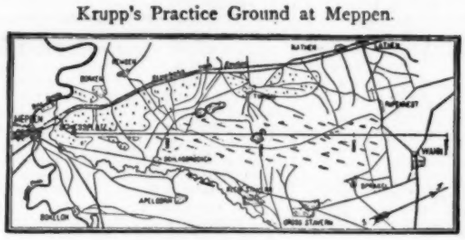
We present three cuts which illustrate in a very graphic manner the course followed by a 9½ inch shot, which was actually fired some years ago at Krupp's practice ground, at Meppen, Germany. They were published by the company and incorporated in their catalogue at the time. The first cut illustrates the flight of the shot across the practice ground. The point at which it fell agreed very closely with the calculated position. The second and third cuts show a plan view and profile of that section of the Alps lying between Pré St. Didier and Chamonix which includes the famous Mont Blanc.

The same gun is supposed to be set up at Pré St. Didier and fired with an elevation of 45 degrees at Chamonix. The shot, weighing nearly one-fourth ton, would rise to an extreme altitude of $4\frac{1}{10}$ miles, or over a mile higher than Mont Blanc, and sweeping across the whole range in a majestic curve, it would fall into Chamonix, $12\frac{4}{10}$ miles from the starting place!

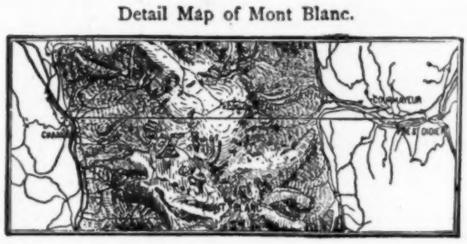
Another famous shot from a smaller gun was that known as the "Jubilee Round," which was fired at Shoeburyness, England, in 1888, the year of the Queen's Jubilee. The gun was a 9·2 inch rifle of the wire wrapped type. A 380 pound shot was fired with a muzzle velocity of 2,360 foot seconds at 45 degrees elevation. The range was 12·4 miles, or almost exactly that of the Krupp gun, and, as in the latter case, the calculated and actual range were surprisingly close.

The possible range of existing guns, not to mention the improved types of the future, may be judged from the fact that the Elswick Works, of Newcastle, England, have turned out a hooped quick-fire gun with which a velocity of 4,928 feet a second has been realized, which is more than twice that of the "Jubilee Shot." This enormous velocity—nearly a mile a second—was obtained from a 6 inch gun, firing 19½ pounds of "cordite."

Krupp's Practice Ground at Meppen.



Detail Map of Mont Blanc.



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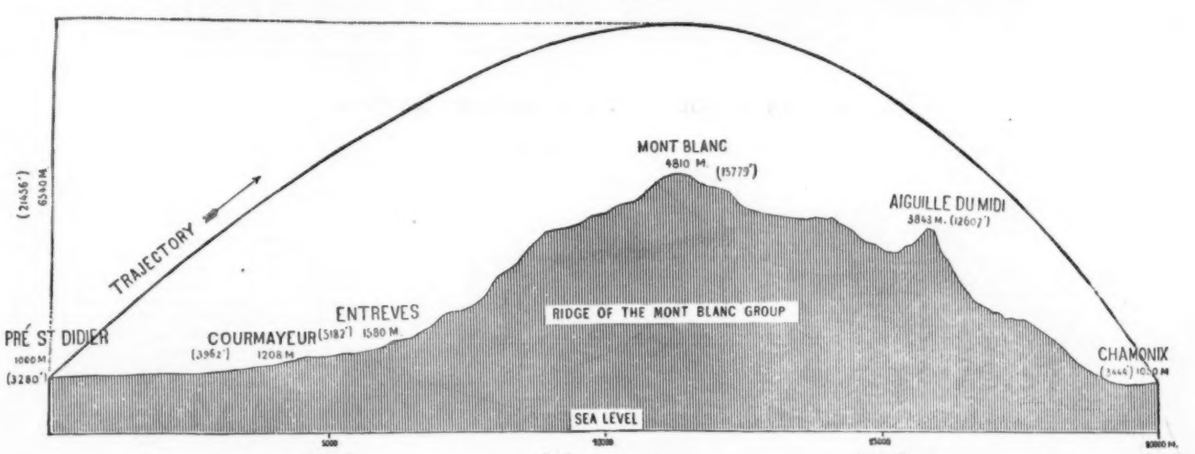


THE FLIGHT OF A MODERN PROJECTILE.

THE BESSEMER PROCESS CONTROVERSY.

Presidential Address by JOS. D. WEEKS.*

THE notable inventions in iron and steel making in the century just closing are Neilson's hot blast, the so-called Bessemer process, the open hearth process and the basic modifications of these latter two. Of these four the most important beyond question is that process whose essential feature is the decarburization of pig iron by blowing atmospheric air through the metal in a molten state, in a word what is called the Bessemer process.

In this presence it is not necessary to speak of the metallurgical importance of this invention. It made possible the rapid manufacture of a malleable product of iron in large quantities and masses, of any carbon, at a low cost. Its commercial and economic importance cannot be measured. The part it has played in facilitating transportation and reducing its cost, and thus binding together nations and states, advancing civilization, and adding to the sum of human comfort and happiness, gives it a rank next to the steam engine. What it has done for labor no one who has watched the exhausting toil of the puddler and the fiery ordeal of the "puller-out" at the crucible furnace need be told. In a literal sense the sweat has been wiped from the face of labor, while for every man it threw out of employment at the finery or puddling furnace it has made work for a thousand at better paid and less exhausting labor.

He who invented this process justly deserves great honor among men. The world, therefore, not always ungrateful, has hastened to pay honor to Bessemer, whom it regards as its inventor, but great as is his desert, he is not the original inventor of the essential and fundamental feature of this process. This credit is claimed for William Kelly, a Pittsburger, who, in 1847, at least seven years before Bessemer discovered the process, claims to have conceived and successfully practiced this invention.

I think it not amiss, therefore, at this meeting of the American Institute of Mining Engineers in Pittsburg, that its president should place before its members the claim of a Pittsburger to be the original inventor of this process, which has done so much to build up Pittsburg's industries, and should state the evidence to support this claim. In doing this I hope I shall in no respect detract from the credit justly due Bessemer and Mushet, and may I not add Fritz and Hunt, and all the others in whom the "flame of good fellowship and affection" is still burning brightly, and Holley and Jones, and all the others "whose living fire has fluttered thin and pale at the lips" and "whom loving hands have turned down that they may be cast in a better mould."

Before presenting the evidence to support Mr. Kelly's claim, there are two preliminary questions that should be discussed.

1. Who is the original inventor of a process?
2. What is the essential or fundamental principle or idea of the so-called Bessemer process?

This will lead—

3. To the statement of Mr. Kelly's claim to be the original inventor of this process, of the evidence to prove this claim, and to the discussion of this evidence.

First.—Who is the original inventor of a process?

This question has frequently been passed upon by the Supreme Court of the United States, which has again and again held that every invention contains two elements:

(1) An idea conceived by the inventor. (2) An application of that idea to the production of a practical result. Neither of these elements is alone sufficient. An unapplied idea is not an invention. (See Robinson on Patents, Book 1, Prgf. 77.) The inventor, therefore, is the one who conceives an idea and successfully practices it, and the original or first inventor is the one who first does these two things.

Further, our Supreme Court holds that an inventor does not have to state, nor even recognize, all the results of the invention in order that he may claim these results. "An invention, though made only for one purpose, is sometimes capable of serving many." "That these modes of employing his invention are unforeseen does not affect his position or his rights as an inventor so far as his invention is concerned. The law regards him as the owner of the invention for any and every purpose to which it can be applied, and thus secures to him the entire benefit of his original idea." (Robinson on Patents.)

Second.—What is the essential or fundamental principle or idea of the so-called Bessemer process?

No one will doubt the competency of Alexander L. Holley to answer this question. He said in 1871, "The essential feature is the decarburization of crude cast iron by the air blast in a vessel independent from the blast furnace or furnace in which it was melted and without the application of external heat."

Bessemer's claim in his first United States patent (No. 16,082, dated November 11, 1856, which is in effect the same as his English patents dated October 11, 1855), is as follows:

"The conversion of molten crude iron or of remelted pig or finery iron into steel or into malleable iron, without the use of fuel for reheating or continuing to

* Annual presidential address delivered at the Pittsburg meeting of the American Institute of Mining Engineers, and published in the American Manufacturer.

heat the crude molten meltal, such conversion being effected by forcing into and among the particles of a mass of molten iron currents of air or gaseous matter containing or capable of evolving sufficient oxygen to keep up the combustion of the carbon contained in the iron till the conversion is accomplished."

Kelly's claim in his first United States patent (No. 17,628, dated June 23, 1857, reissued No. 505, dated November 3, 1857) is as follows:

"Blowing blasts of air, either hot or cold, up and through a mass of liquid iron (the oxygen in the air combining with the carbon in the iron causing a greatly increased heat and ebullition in the fluid mass), and decarburizing and refinishing said iron without the use of fuel."

Note.—The word "refinishing" in the last line is evidently a misprint for refining.

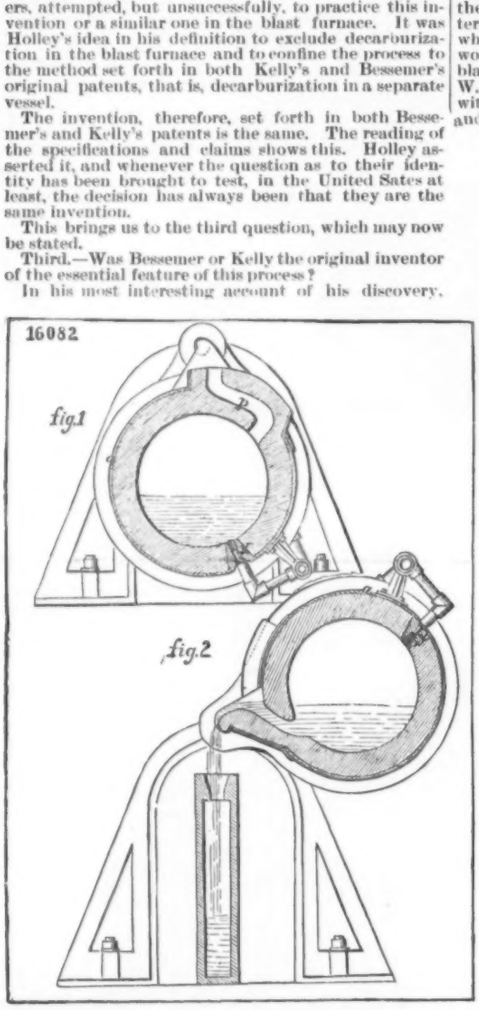
It will be noted that these two claims are in effect for the same invention, and that it is the invention set forth in Holley's statement. The only difference between Holley's definition and these claims is that Holley requires that the conversion shall be made in a vessel separate from the furnace in which the iron is made or melted; while the claims do not require this, yet, as will be seen from the specifications, this was really the idea in the original patents of both Kelly and Bessemer. Both these inventors, however, as well as others, attempted, but unsuccessfully, to practice this invention or a similar one in the blast furnace. It was Holley's idea in his definition to exclude decarburization in the blast furnace and to confine the process to the method set forth in both Kelly's and Bessemer's original patents, that is, decarburization in a separate vessel.

The invention, therefore, set forth in both Bessemer's and Kelly's patents is the same. The reading of the specifications and claims shows this. Holley asserted it, and whenever the question as to their identity has been brought to test, in the United Sates at least, the decision has always been that they are the same invention.

This brings us to the third question, which may now be stated.

Third.—Was Bessemer or Kelly the original inventor of the essential feature of this process?

In his most interesting account of his discovery,



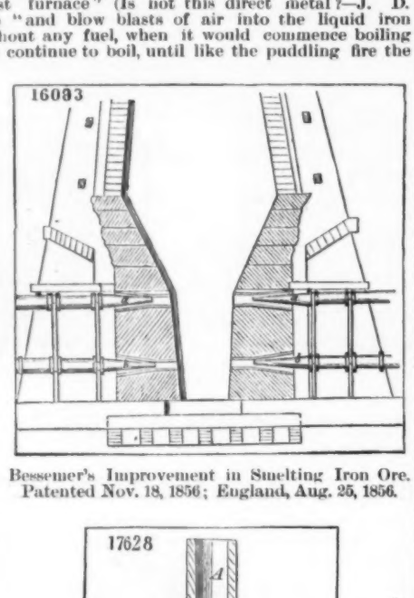
Bessemer's Original Patent. Patented in the United States Nov. 11, 1856; in England, Feb. 12, 1856.

published in our Proceedings (vol. xix, pages 809 to 830), Mr. Bessemer gives no date for his invention. He says, however, that the suggestion that led up to his discovery grew out of conversations during the Crimean war with Emperor Napoleon III. Prince Napoleon and others, and especially Minié, the inventor of the rifle bearing his name, regarding the necessity for a better material for artillery guns. As this war began in 1854 and ended in 1856, the earliest possible date of the first conception of his invention must, therefore, according to his own statement, be 1854. His first patent was taken out June, 1855. This included the use of the steam blast as well as the air blast, as did also the patent upon which his claim chiefly rests, which is dated October 11, 1855. The date of Mr. Bessemer's invention of the pneumatic process, therefore, is not earlier than 1854, possibly not earlier than 1855.

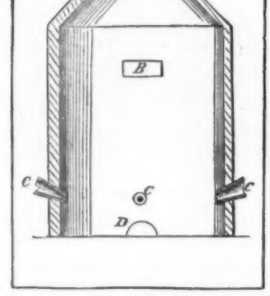
What is the date of Mr. Keliy's invention of this process?

At the Cheltenham meeting of the British Association in 1856 Mr. Bessemer read a paper on his invention which aroused the most widespread interest and marked the beginning of an epoch in the history of steel. In some way the facts contained in this paper were brought to the attention of Mr. William Kelly, at that time operating the Suwanee Furnace, near Eddyville, Ky. He at once recognized the process as one that he had invented some years before and had been experimenting with at his furnace and forge. He immediately applied for a patent, but Bessemer was ahead of him in the United States Patent Office and had been granted a patent November 11, 1856. The claim of Kelly was so like that of Bessemer that an interference was at once declared and testimony taken in April, 1857, after due notice to Bessemer. The evidence showed conclusively that Kelly not only conceived this process, but practiced it at his forge near Eddyville as early as 1847, and from 1851 to 1857 at the Suwanee Furnace near the same place. I have carefully read the affidavits in support of his claim, some twenty-two in number, from persons to whom he explained his process, to whom he had shown drawings, who had made patterns and castings for his machinery, who had helped him in his experiments and work, who had ladled the molten metal into his converter or "air boiling furnace" as he termed it, and who had tested the metal after it was made; and if any confidence can be put in human testimony under oath, Kelly invented and practiced this process as early as 1847. I print in full in the appendix six of these affidavits. Mr. Smith, a builder of blast furnaces and a machinist, testifies that in 1847 "Mr. Kelly described to him a new process for treating iron, by which he expected to be able to produce malleable iron from fluid pig metal without fuel by a strong blast of air blown into the liquid mass of iron," and that drawings of the apparatus were shown him. Other affidavits also speak of the tests made at this date, 1847, and of the character of the iron made, which was malleable.

In Dr. Champion's affidavit Kelly's description of the process as given in 1851 at a meeting of iron masters is reported as follows: "His furnace was somewhat like the common cupola furnace, into which he would put a quantity of fluid metal taken from his blast furnace" (Is not this direct metal?—J. D. W.) "and blow blasts of air into the liquid iron without any fuel, when it would commence boiling and continue to boil, until like the puddling fire the iron would be boiled to nature or made malleable." On objection being made that the air would chill the iron, Kelly stated, so Dr. Champion swears, that "instead of chilling up his furnace it would become intensely hot, that the carbon contained in the iron having an affinity for the oxygen, would unite with the oxygen in the blast, and, so united, would create an intense heat and pass off in the form of carbonic acid gas." Others describe the furnace used, and declare that they assisted in ladling the iron into the converter and blowing it to nature.



Bessemer's Improvement in Smelting Iron Ore. Patented Nov. 18, 1856; England, Aug. 25, 1856.



Kelly's Improvement in the Manufacture of Iron. Patented June 23, 1857.

Do not these experiments cover all of the points mentioned in Holley's definition of the essential features of the Bessemer process, viz.: "The decarburization of crude cast iron by the air blast in a vessel independent from the blast furnace or furnace in which it was melted and without the application of external heat"? And if Kelly did this in 1847, while Bessemer did not conceive the idea until, at the earliest, 1854, is not Kelly the original inventor of the so-called Bessemer process, and in calling it the Bessemer process, has not Kelly been unfairly deprived of the credit due him, as was Columbus when this continent was named America?

As stated above, the question as to Kelly's priority of invention of the pneumatic process has twice been before the United States Patent Office for judication.

In the matter of the interference between Bessemer's patents and Kelly's application above noted, the acting Commissioner of Patents states under date of April 11, 1857:

"It appears that by the concurrent testimony of numerous witnesses Kelly made his invention and showed it by drawings and experiments as early as 1847, and this testimony appears to be reliable in every respect.

"The patent of Bessemer was sealed at London on April 11, 1856, and bears date October 11, 1855.

"Priority of invention in this case is awarded to said Kelly and it is ordered that a patent be issued accordingly unless an appeal be taken within 60 days from this date."

No appeal was taken, and on June 13, 1857, the patent was issued to Kelly.

In 1871 this patent came up, under the patent law then existing, for extension. A mass of testimony was then taken, some to the effect that the invention was neither new nor useful; other, that Kelly had been anticipated by Bessemer and others. While all the objections usual in such cases were raised against the extension, after a careful hearing, Mr. Kelly's patent was extended. The report of B. S. Hedrick, the examiner, to the Committee of Patents, dated June 7, 1871, is given in Appendix IX. In this brief, which is well worth reading, the examiner says: "Kelly's own statement of the history of his invention is full and clear, and, when taken in connection with the statement of the witnesses, seems to be both intelligent and truthful." On the report of Mr. Hedrick as stated above, the extension asked for by Mr. Kelly was granted.

In examining the files in connection with the application for this extension, an affidavit of more than usual importance was found. It is also of interest to us of the American Institute of Mining Engineers by reason of the name attached to it, Alexander L. Holley. Regarding this point of the priority of Kelly's invention over that of Bessemer, listen to the words of him whose voice has been so often heard in our meetings, but which, alas! is now silent forever. Holley said:

"I consider Kelly's invention the first practical development of the pneumatic process, and it has been so recognized by the owners of the combined patents covering this process, Mr. Bessemer, by his superior mechanical improvements and capital, anticipated the results which might naturally have followed from the development of the Kelly process."

These are the words of the engineer who better than any one else knew the merits of the claims of Kelly and Bessemer to priority of invention, and he unhesitatingly ascribes priority to Kelly.

There is one other point that should be touched upon. In examining the statements made by Kelly and Bessemer or in their interest, one peculiar fact will be noticed: that is, that Bessemer seems to have been seeking to produce steel by his invention, while Kelly sought to produce malleable or wrought iron, though both speak of iron and steel. This is perfectly natural, in view of the object each had in his experiment; Mr. Bessemer was seeking a material for a gun and was led in the direction of his invention by a desire to procure steel; Mr. Kelly was a forge-master, making malleable or wrought iron, and it was to make this product that he pursued his experiments. This fact has led some persons to give Mr. Bessemer the credit of the invention of the process for steel making because Kelly sought only malleable iron.

This claim, however, will hardly hold. As we have pointed out in discussing our first question, it is a well recognized principle that an inventor is entitled to all the results of his invention, even though he does not state them nor even recognize them; the invention is his for any and every purpose to which it can be applied, and consequently Kelly is entitled to the credit of his invention as a steel-making process, as well as a malleable iron-making process. Further, it must be remembered that the word "steel" had not the same meaning in 1847 that it has to-day. Steel then meant chiefly a product that would harden and temper and that could be made into edge tools, and not what we know to-day as steel, which is any cast product of iron that is malleable. The material that Kelly made by his process in his converter, no matter what he called it, must of a necessity be what we to-day would call steel; it was a cast malleable product of iron. It seems to us, therefore, that Kelly made steel as truly as Bessemer made steel.

In claiming for Mr. Kelly this great honor I do not wish to detract in the least from the credit justly due Sir Henry Bessemer. The mechanical methods and appliances suggested and invented by Bessemer—and it is on these that his claim to honor justly rests—were as necessary to the completion, commercially, of the process, as was its invention. As Mr. Holley puts it, "Mr. Bessemer's invention consisted in the mechanical means for intimately diffusing the air through the mass of iron to such an extent that the chemical changes take place with sufficient rapidity to leave the mass fluid after the carbon and silicon have been removed; while the means employed by Mr. Kelly were not adequate to carry the process to the same extent."

The superiority of Bessemer's mechanical methods and appliances to those of Kelly is evident at once to one who studies the history of these inventions. After years of experiment Kelly had not got beyond the fixed converter. As late as 1856, after nine years of work, the appliances he used were exceedingly crude. Mr. John E. Fry, who was a foundry moulder at Cambria when the first experiments were made at Johnstown by Kelly, in a conversation a few days since, thus described the first converter used there in 1856:

"The apparatus was a two-foot section of a three-foot boiler shell lined up to about 16 inches inside diameter with fire brick, having a paved fire brick bottom, about 20 inches deep. This was put just outside of the door of the blast engine room of the old Cambria blast furnace. The engines gave from three to four pounds blast pressure. There was a temporary connection made from the blast pipe to this little auxiliary furnace by a gas pipe. The nozzle was a cast iron affair, such as was used at the tuyeres in those days. The tuyere was 'clayed up' and dried and connected by a loose elbow to the pipe so as to be swung down into the metal. The metal was melted at the foundry and brought up in a ladle containing about 500 pounds. The furnace was about 200 yards from the foundry, and the ladle was put on a little metal-hauling car and hauled to the converter. This metal would make probably eight or nine inches of depth in this little pot. As soon as the metal was dumped in, the pipe was shoved down with the blast

on. A cover of pieces of sheet iron was laid across the top to prevent the sparks flying too freely."

In 1858 the apparatus used at Cambria, while more permanent, was still exceedingly crude, as will be seen from an inspection of the 1858 converter herewith shown. It is made up of three rings of a roll flask, on which are placed a ring of a pinion flask and the top of what was known in foundries as a "cannon" heating stove. It was not until 1861 that a movable converter was erected in the United States, at Cambria, and this is an infringement on Bessemer's converter. It was, however, the pioneer commercially successful converter of this country.

Bessemer's converter, also, was at first fixed, but it is a vastly different piece of apparatus from the Kelly converter. Moreover, the records of the Patent Office show that Bessemer very soon discarded this for the movable rotary converter, which is practically the vessel still used.

Bessemer, therefore, is entitled to the greatest credit for the early mechanical appliances and methods which have done so much to make this process successful.

But every steel maker knows that the decarburization process and the mechanical appliances were not all that were needed to make the manufacture of steel by this process a commercial success. Mushet's use of the so-called triple compound of iron, manganese and carbon was as necessary as the process and mechanical appliances. Mr. Bessemer had desiliconized and decarburized his molten cast iron, but the oxygen left in the metal by his powerful blast prevented the production of even good iron, while the absence of carbon was fatal to the production both of iron and steel. In 1857 Mushet produced by the addition of his triple compound or spiegeleisen from Bessemerized hematite cast iron, which he melted in crucible steel making pots, ingots of good steel weighing 500 to 600 pounds. One of these ingots was rolled at Ebbw Vale into a rail which was laid—the first Bessemer steel rail ever laid in the world—at Derby, England, on the Midland Railroad. In 1873, 16 years afterward, this rail was taken out after 1,250,000 trains had passed over it. It was this invention of Mushet's that was necessary to complete the great triology in the quest of steel, and a treasure greater than that of the Niebelungen, and beneficial, not harmful, to man, was found.

To sum up, while the mechanical appliances that made possible the rapid production of pneumatic steel were Bessemer's, of London, and while the idea of using spiegeleisen to remove the oxygen and to recarbonize the metal was Mushet's, of Cheltenham, the original idea of decarburization by blasts of air was William Kelly's, of Pittsburg.

SIR HENRY BESSEMER'S ANSWER TO MR. WEEKS.*

TO THE EDITOR OF ENGINEERING.

SIR: A presidential address has recently been delivered at Pittsburg to the American Institute of Mining Engineers by Mr. J. D. Weeks, who has taken advantage of that prominent position as president to repudiate my just claims to the steel invention that bears my name, and which has been most amply acknowledged by America's most honored scientific institutions, manufacturers and citizens during the last forty years. I may not inaptly preface the remarks I have to make on this subject by the words of our immortal bard:

> "Who steals my purse, steals trash,
> 'Twas mine, 'tis his, and has been slave to thousands,
> But he who filches from me my good name
> Robs me of that which not enriches him,
> And makes me poor indeed."

A great moral responsibility is incurred by the man who, for the mere purpose of gaining a short lived popularity, does not hesitate to blast the reputation of one who he well knows in his own heart is the real inventor of that process which has so enormously extended the trade and commerce of his own country, and for this unworthy object flatters his hearers by telling them that they owe all this to a countryman of their own; taking the opportunity of making these statements at a public meeting at which I necessarily could not be present, and relying for this monstrous accusation upon such vague testimony as he has been able to rake up from bygone transactions touching only one side of the question. Mr. Weeks well knew that a period of forty years, and the wide Atlantic, separate me from all documentary evidence on my side of the case, and which, at the period when all the facts on both sides were before the American people, they had, to their great honor, decided in my favor, and to which opinion they have adhered up to the present day.

Fortunately, however, for me, some of the evidence which Mr. Weeks brings forward to support the case of Mr. Kelly, from the very nature of things, furnishes conclusive evidence against the allegations which he makes in favor of Kelly's scheme, and in order that the whole subject may be clearly understood, it is necessary for me to refer to some technical details of iron making, showing their close analogy with the process said to have been carried out by Kelly.

For the last hundred years or more, it has been the practice of manufacturers of malleable iron to operate upon the crude pig iron in a small shallow bath, known as a refinery, or "finery fire," in which the molten pig iron is subjected to a blast of air blown down upon its upper surface from three nozzles arranged along the side of the bath, or pool, of iron, the surface of which has a quantity of incandescent coke floating upon it. After this blowing operation has been continued for an hour or two, the molten matter is to some extent decarburized and partially deprived of its silicon; it is then run out and formed into thick plates, which, when cold, are very hard and brittle white iron; these plates are broken up and reheated in a reverberatory furnace, and rendered malleable by the laborious process of puddling. We hear that a Mr. Kelly was making some experiments of this kind as far back as the year 1847, and we are told by the president, Mr. Weeks, that "Kelly was a forge master making malleable or wrought iron, and it was to make this product that he pursued his experiments," so that, according to the evidence furnished by Mr. Weeks himself, Kelly did not contemplate the production, or even try to produce steel by his experiments, as that material was quite out of his line of business.

But it is cast steel, such as Bessemer invented (and perfected the process of making in every mechanical detail), that has played such an important part in the metallurgy of the present century; it was this cast steel, and not the wrought iron which Kelly was trying to improve, that has laid the 170,000 miles of steel rails like a network over the whole continent of America; it was this cast steel made by the Bessemer process, and the machinery invented by him, with which the 4,160,072 tons of cast steel was made in America in the year 1872, and not by any plan or device originated or practiced by Mr. Kelly.

Now, what could be more natural for a forge master and manufacturer of wrought iron than to try and save some of the fuel used in the ordinary process of his trade? and what would appear more obvious than the idea that some, or perhaps all, of this incandescent coke lying on the molten pig iron in the "finery furnace" might be saved? This doubtless was the sole and simple object which Kelly had in view when he was trying experiments in his open yard, as described by Mr. Weeks, operating in a very temporary way and using the end of an old boiler lined up with bricks and containing about 500 lb. of molten iron from the blast furnace—just such a charge as when refined would be enough to make a charge for the puddling process which had to follow, and thus to make it into malleable or wrought iron, which Mr. Weeks tells us was Kelly's trade "and what he was trying to make." This was just such an experiment as might be safely made without previously taking the precaution of patenting it, as its value, if successful, would be very small. The apparatus, he tells us, was provided with a single nozzle blowing vertically down upon the metal, and which single jet of air blown down upon it would partially, though very imperfectly, refine it, as is done in the "finery fire" in common use.

When this scheme, which had long been utterly abandoned and forgotten, was investigated some eight or nine years after these experiments had been made, all the evidence which I could collect went to show beyond all reasonable doubt that Kelly was simply trying to make his "finery iron or plate metal" without the employment of any coke floating on the surface, and thus saving some fuel in preparing his metal for subsequent conversion into malleable iron.

This is the impression which was irresistibly forced on my mind at the time these questions were before the American Patent Office, and I have at this moment the most absolutely conscientious belief that Kelly was not at that period even attempting to produce fluid malleable iron or steel in a fluid state such as could be formed into ingots or castings.

And when we read the strongly biased statements of Mr. Weeks and note his all-important omissions, his own story furnishes me with an absolute denial of his most unwarrantable assertion that Kelly had originated the Bessemer process.

One would have thought that if Mr. Kelly commenced his experiments in 1847 we should have heard something of this revolutionary process before the year 1856, but we are told that "as late as 1856, after nine years of work, the appliances he used were exceedingly crude." Mr. John E. Fry, who was a foundry moulder at Cambria when the first experiments were made at Johnstown by Kelly, "in a conversation a few days since," thus described the first converter made in 1856 to Mr. Weeks:

"This apparatus was a 2 ft. section of a 3 ft. boiler shell, lined up to about 16 in. in diameter, having a paved firebrick bottom about 20 in. deep; this was put outside the door of the blast engine room of the old Cambria blast furnace. The engines gave from 3 lb. to 4 lb. blast pressure; there was a temporary connection made from the blast pipe to this little auxiliary furnace by a gas pipe. The nozzle was a cast iron affair, such as was used at the tuyeres in those days. The tuyere was 'clayed up' and dried and connected by a loose elbow to the pipe, so as to be swung down into the metal. The metal was melted at the foundry and brought up in a ladle containing about 500 lb. The furnace was about 200 yards from the foundry, and the ladle was put on to a little metal-hauling car and hauled to the converter; this metal would make probably 8 in. or 9 in. of depth in this little pot. As soon as the metal was dumped in, the pipe was shoved down with the blast on, a cover of pieces of sheet iron was laid across the top to prevent the sparks flying too freely."

And here the evidence drops short, for it is clearly not worth their while to pursue the subject any further: it would be dangerous to do so; it would, in fact, "let the cat out of the bag." These discreet witnesses have given all the very interesting details as to the "dumping" in of the molten iron, even to the kind of "little hauling car" which conveyed the metal to the apparatus; but it would have been infinitely more to the purpose if they had told us something about the way in which this metal was taken out again, in what state of partial or complete solidity was it obtained, and whether it was soft malleable iron or hard and brittle "plate metal." They have told us nothing of the use of ingot moulds, in which the molten malleable iron must be made ingot; they have told us nothing of the treatment of the metal after it was blown. Was it taken to the puddling furnace to be there converted into wrought iron, or was it rolled into bars or sheets from ingots formed while in a fluid state? Without all these essential facts all their testimony and affidavits are worse than waste paper, as they directly prove nothing; but the absence of these facts affords very strong circumstantial evidence that Kelly never had produced homogeneous malleable iron, and had never made an ingot by his process.

Kelly's method of operating by one tuyere only, blowing vertically downward, shows that he had never grasped the fundamental principles on which the Bessemer process is based; his nine years of failure show that in all that time he had not mastered the A B C of the Bessemer process. Now there is such a thing as blowing and blowing, and as we are told in the old fable, by simply blowing a man may either "warm his fingers or cool his broth."

But Mr. Kelly saw none of these nice distinctions, and to compensate for this want of knowledge, Mr. Weeks, with much perverted ingenuity, has striven to whittle down the Bessemer process until it is low enough to reach Mr. Kelly's level, and strives to impress on his hearers the idea that the Bessemer process is summed up in the words "blowing air into iron," and Kelly having done this is therefore, according to Mr. Weeks' theory, on Bessemer's level. This, however, is not so; the mere blowing of air into a fluid is not a patentable suggestion, it is not a "new manufacture," and before we can obtain a valid patent, we must produce something tangible, something not before produced by the same means, something which is, in fact, either of better quality or less in cost than has been produced by former methods. "I therefore claim as my invention the forcing of currents of air into and among the particles of molten crude iron, or of remelted pig or refined iron, until the metal so treated is rendered malleable and has acquired other properties common to cast steel, and still retaining the fluid state of such metal, and pouring or running the same into suitable moulds," and so obtaining a "new manufacture."

Now, blowing air into a fluid mass is not a manufacture at all, and therefore is not patentable; thus, for instance, you may blow heated air into linseed oil, but that is not a new manufacture, such blowing might be simply to warm the oil; but if you blow air in a heated state in numerous divided streams upward from a perforated coil, lying at the bottom of a tall cylindrical vessel filled with linseed oil, the oil so treated will combine with the oxygen of the air and become viscid and tenacious, and will acquire the same drying quality as oil that has been boiled with oxide of lead in the usual way of making drying oils, and hence such a process of blowing air into oil by its chemical action produced a superior drying oil and was a new and patentable manufacture; this was an invention of mine ten years before I thought of steel making, and for which invention I reaped my reward.

Again, if you blow cold air in numerous jets upward through a vessel filled with cream, that is in itself not a new manufacture, but if your streams of air are powerful enough, and sufficiently long continued, the violent agitation caused thereby will convert the cream into butter, and result in the production of butter without churning; this becomes a new manufacture capable of being secured by patent. The different effects produced by different modes of blowing are well exemplified in the old Catalan furnace used in iron making, where the blast is made carbonizing or oxidizing by merely altering the angle at which the tuyere is directed through the fuel, and by means of which adjustment of angle the workman regulates his process. Again, in the old "finery fire" the tuyeres blow down on to the metal at such an angle as will throw the metal to the opposite side of the bath, and insure a rapid circulation of all the metal under operation, without which this old process of "blowing iron" would entirely fail. All this is mere matter of history, but, being known, it serves to show the entire want of ingenuity and mechanical skill, and the complete absence in the mind of Kelly of the most simple and rudimentary knowledge on the subject of the motion of fluids impelled by currents of air, as is clearly shown by his choice of the vertical position of the tuyere, in blowing on to or into fluid iron. Kelly appears to have adhered from first to last to this fatal mistake of using one tuyere only, and that one operating in the very worst position in which it was possible to place it; a position most certain of all others to insure its own rapid destruction while producing the least possible circulation and effect on the metal. An enormously high temperature is necessary not only to render pure iron fluid, but an excess over that temperature is necessary to allow it to be transferred to a casting ladle, and therein be retained in a fluid state during the time necessary to quietly pour it into numerous moulds. The great problem I had to solve was how to generate and retain this enormously high temperature, for on any system of heating fluids we have two antagonistic operations going on, viz., the production of heat and its loss by radiation and absorption by the vessel in which the process takes place, and this particular case is further complicated by the rapid absorption and carrying off of heat by the incombustible portion of the air forced through the metal, hence it becomes a question of time; heat is always flowing away, and if the accession of heat went on at the same pace, we should never raise the temperature of the metal, and this points at once to the necessity for an extremely rapid production of heat; this rapid production of heat means such an intimate admixture of the combustible carbon and silicon with oxygen as will produce the necessary temperature in a few minutes, otherwise the heat would be dissipated and the fluidity could not be maintained. So intimate is the mixture of carbon and oxygen in gunpowder that its combustion becomes instantaneous and no heat is lost, and in the Bessemer converter a well arranged set of tuyeres blowing vertically upward produces such an intimate admixture of oxygen and carbon as to create a succession of small harmless explosions, and hence fixes a limit to the safe diffusion of these combustible elements.

A converter with a group of seven tuyeres, each having seven separate passages through them, will direct vertically upward forty-nine separate streams of air through the metal; this air dividing itself into countless thousands of small globules rushes upward, producing a light column of mixed iron and air, while the denser portions of the iron form descending columns and keep up a powerful circulation, equalizing the temperature and the rate of combustion; but a single nozzle pointing downward, as tried by Kelly, will not diffuse the air throughout the mass, but the air will rise up around the nozzle and soon melt and destroy it. Air applied in this manner can never set up that amount of circulation and vivid combustion throughout the whole mass which is an absolute necessity if fluid malleable iron is to be produced and cast into ingots, conditions absolutely impossible to arrive at in a shallow open vessel with one tuyere blown downward.

Indeed, Mr. Weeks is constrained to admit that Kelly could not make fluid malleable iron in his apparatus owing to its inherent defects in principle, which Kelly

* From London Engineering.

had not scientific knowledge enough to perceive or mechanical skill enough to remedy.

The precise words which Mr. Weeks adopts from Mr. Holley in his confession of the failure of Kelly to produce fluid malleable iron are as follows: "Mr. Bessemer's invention consists in the mechanical means for intimately diffusing the air through the mass of iron to such an extent that the mechanical changes take place with sufficient rapidity to leave the mass fluid after the carbon and silicon have been removed; while the means employed by Kelly were not adequate to carry the process to the same extent." Hence with his one tuyere blowing downward, Kelly could not, and did not, produce fluid malleable iron; and could not, and did not, make an ingot; and could not, and did not, carry out the Bessemer process, which consists in the production of ingots of cast steel by forcing numerous streams of air upward through the molten crude or cast iron; this failure of Kelly was the result of his entire ignorance of the essential principle on which the Bessemer process is based, viz., the rapid diffusion of minute fiery bubbles throughout the entire body of the metal under operation.

This abortive attempt of Kelly (if ever made) was by Mr. Weeks' own showing abandoned some years before I read my Cheltenham paper, having never served any useful purpose whatever.

Had Kelly patented his invention, had he read a paper on it before any scientific institution, or had he published an account of it in the public press, it might have been said that a published account of even this most unsuccessful and abortive attempt would have acted on other minds and suggested a more perfect system. But Kelly did not in either of these ways, or in any other way, make known or convey any knowledge to the outer world as to what he was trying to do, and hence his labors have not by the smallest possible increment advanced the general stock of knowledge, or influenced to the most infinitesimal extent the progress of steel making, either in America or elsewhere. All that Mr. Weeks has succeeded in doing is to show that as an American citizen, if he ever had in his mind the idea that malleable iron could be produced by currents of air, could yet be so entirely devoid of mechanical skill, so hopelessly ignorant of the physical laws which govern the whole theory on which my invention is based, that, after pottering over his ill-devised schemes for a number of years, he failed hopelessly, and gave it up, having never benefited the world to the smallest possible extent. He never even thought it worth while to patent his invention during all the nine years from 1847 to 1856; but as soon as he found that my invention was agitating the whole iron trade of Great Britain, he woke up and commenced a fierce fight with affidavits in the American Patent Office, after I had already obtained my patent in America, and after all my English patents were published in blue books, which at the small cost of 6d. each were open to Kelly's and every one else's inspection; in them they could see every detail of my several inventions. Then it was, we are told, that "Pompey was very like Cæsar," and that there was a wonderful identity between Kelly's invention and mine; but this similarity did not come about by my patenting in America an apparatus with one tuyere blowing downward.

Any one would have thought that a person in Mr. Weeks' position must have had the honor of his own country more at heart than to drag such a lame and disgraceful story from the obscurity in which, to the honor of America, it had for forty years been buried.

The fact of Kelly obtaining a patent in America after mine rendered it necessary for all the manufacturers of steel in America to work under both patents, so all the trade knew perfectly well what Kelly's title to be called an inventor really was, and with this full knowledge they unanimously joined in always calling it the Bessemer process. The Americans have, with this knowledge before them, elected me an honorary member of the American Society of Mechanical Engineers, and also an honorary member of the American Academy of Arts and Sciences, "and in several parts of the United States, where nature has richly endowed them with those aids to civilization, coal and iron, manufacturing cities have been established to which, by common consent, they have given the name of Bessemer.

"Thus we have the rapidly increasing and important city of Bessemer, Gogebic County, Michigan; the city of Bessemer, Alabama, with its mayor and corporation, its street tramways and electric lighting, and its large manufacturing works, public schools and numerous churches. There is also the city of Bessemer, Lawrence County, Pennsylvania, the seat of the great Edgar Thomson steel works, the largest in America. There is also the city of Bessemer, Botetourt County, Virginia, and the city of Bessemer, Gaston County, North Carolina."

Nothing could more clearly show the spontaneous recognition by a whole nation of the enormous benefit that the Bessemer process has conferred on the trade and commerce of the United States.

The great wave of excitement produced on the public mind throughout Europe by the announcement of my invention at Cheltenham soon forced its way across the Atlantic, and created a great sensation among the iron producers of the United States; among other eminent men it attracted the most earnest attention of Mr. A. S. Hewitt, whose high position is fully recognized throughout the United States, and who made the following statement in reply to Sir James Kitson, the honored President of the Iron and Steel Institute, when Sir James was in America in 1891. Mr. Hewitt said: "Mr. Bessemer read his celebrated paper describing the process of producing steel without fuel at the Cheltenham meeting of the British Association for the Advancement of Science in the summer of 1856. An imperfect report of this paper was published in the journals of the day, and attracted my notice. The theory announced seemed to be entirely sound, and the apparatus simple and effective. I gave orders at once, without further information than that derived from the published report, to erect an experimental vessel for the purpose of testing the possibility of producing steel direct from the blast furnace. In the same year in which this paper was read, the experiment was tried at the furnace of Cooper & Hewitt at Phillipsburg in New Jersey, and the result served to show beyond all doubt that the invention of Mr. Bessemer was one which could be successfully reduced to practice."

Now, if Kelly's nine years' pottering had created the smallest interest in America, surely a firm like Cooper & Hewitt would have known it and would not have been so anxious to prove the fact as at once to have put a Bessemer converter in operation on an experimental scale.

Mr. A. S. Hewitt, who is a past president of the American Institute of Mining Engineers, said on the occasion of their meeting at Washington on February 22, 1882: "My firm made an effort within six weeks after the famous Cheltenham paper was read in 1856, to see whether pig iron could be thus converted into steel. It was three or four years after that, that Mr. Holley's attention was called to the matter, and he went to Europe and brought back for his friends the control of that patent."

So that Mr. Holley was not in any way interested in this question for some years after Kelly knew all about my several patents, and Kelly had plenty of time to shape his invention so as to square with mine, even to the making of a movable converter, which Mr. Weeks admits was "an infringement on Bessemer's converter." It is something to get from Mr. Weeks the direct admission that Kelly had made an infringement upon my patent. Why is he not more candid?

No sooner were Bessemer steel rails produced in Sheffield, than American railway managers began to purchase them, and so important were they deemed to be that thousands of tons were sent to America, realizing the almost fabulous price of 20l. per ton; and when America began to make their own steel rails, thousands and tens of thousands of tons of Bessemer pig iron were sent to America from this country to make Bessemer steel with. This Bessemer pig was made by furnace charges invented and dictated by me, all the hematite iron previously made in England entirely failing to make workable steel.

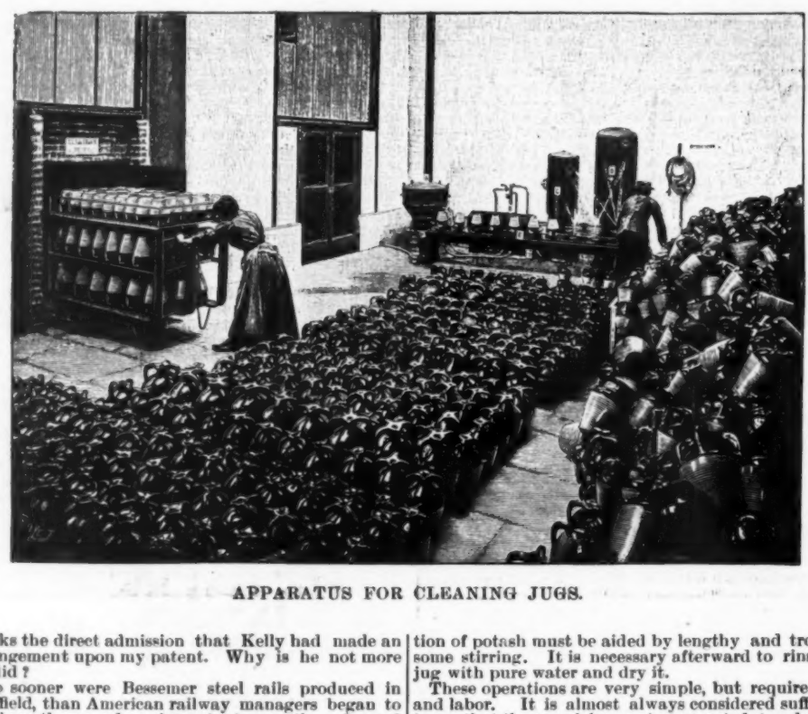
Nor must it be forgotten that the Bessemer converter with its hydraulic moving gear and the hydraulic casting crane and apparatus, the ingot cranes, the valvular casting ladles, pair of vessels arranged in a semicircular pit, the conical moulds, and, in fact, the whole plant, outfit, and arrangements of the American steel works, are the patented inventions of Henry Bessemer, although somewhat modified in their mechanical details by the late Mr. A. L. Holley, so as to suit the American practice, but Bessemer's patent machinery is still used, with scarcely a deviation in detail after a period of nearly forty years, in every country in Europe where Bessemer "steel is made."

The British Patent Office shows all the successive steps in the development of my invention, and with these evidences of its origin and vitality scattered over Europe and America, it is simply an outrage on the man who has done all this, and to whom America is so deeply indebted for the great extension of her manufactures, her commerce, and her prosperity, to set up as the original inventor of the Bessemer process a man whose abortive schemes have not added one tittle to the public store of knowledge, or benefited the world or even his own country to the value of a single cent; it is nothing less than an outrage on the common sense of the scientific world. Yours truly,

HENRY BESSEMER.

APPARATUS FOR CLEANING AND FILLING JUGS.

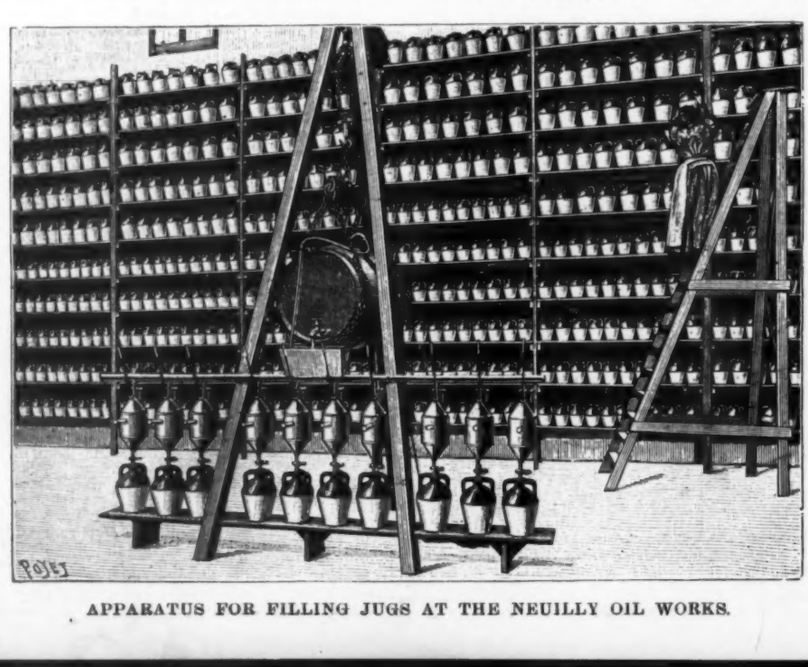
THE cleaning of jugs that have contained oil is quite a laborious operation. The action of a hot solution of potash must be aided by lengthy and troublesome stirring. It is necessary afterward to rinse the jug with pure water and dry it.



APPARATUS FOR CLEANING JUGS.

These operations are very simple, but require time and labor. It is almost always considered sufficient to see that the vessel has not contracted too bad an odor. If it smells bad, it is, in order to expedite matters and avoid drying, rinsed with a little oil, always the same, which thus becomes charged with microbes derived from ill kept houses and distributes them uniformly to the customers. In order to effect a perfect cleaning, the large oil mill of Neuilly has devised a system that solves the question in a complete and very satisfactory manner. The principle of the apparatus consists in the injection into each jug, first, of a large quantity of a boiling solution of potash at considerable pressure and in a large number of regularly distributed jets, and then of a quantity of filtered water. Ten jugs are operated upon at a time, rotary motion being given to each of them around its axis in order that every part of the internal surface may pass several times under a jet, easily and without fail. This result is obtained as follows:

The cleaning apparatus, properly so called, consists



APPARATUS FOR FILLING JUGS AT THE NEUILLY OIL WORKS.

of a large horizontal iron pipe carrying ten small steel tubes closed at the top and each provided with 110 small apertures. These small tubes serve as an axis to small revolving iron stars. One of the points of the star, which is longer than the others, is provided with a vertical aperture at the extremity.

A large horizontal iron rod actuated by a lever carries as many vertical pivots as there are stars, and each of which introduces itself with regularity into the aperture in the star.

By maneuvering the lever to the right and left, an alternating motion is communicated to each star through the large rod. The 110 small jets thus strike with force every portion of the internal surface of the jug placed upside down upon the star, the small vertical tube entering the interior with great precision.

In the first place there is injected, under a pressure of two atmospheres, a boiling solution of potash, which, as it issues from the jug, falls into a large gutter that leads it to a conduit movable around a horizontal axis, whence it flows into a reservoir situated in a room below.

This solution is raised again to its normal degree of concentration in order to be used anew.

After this treatment with potash, filtered water is forced in under a pressure of two atmospheres. The water falls into the gutter, and, the conduit being made to tilt, the liquid is sent directly to the sewer. Each jug receives thirteen quarts of solution of potash and the same quantity of water.

In order to heat the solution, it is led into a boiler by a special pipe. Thence it flows into a reservoir situated at a lower level. It is afterward brought into contact with air compressed to two atmospheres.

The compressed air is obtained very simply by causing the city water to flow under pressure into a reservoir full of air at the pressure of the atmosphere. This air forced into the reservoir raises to two atmospheres the pressure of the air expanded by the preceding operation.

From this it will be seen that the forcing pressure is not constant. It would be necessary for this that the volume of the compressed air should be infinitely great with respect to that of the forcing reservoir. In practice, by giving the first reservoir a capacity double that of the second, very satisfactory results are obtained.

The reservoir is a simple compressed air accumulator. The city water under pressure compresses the air at the upper part of the reservoir, and it suffices to open a cock in order to obtain the force necessary for the simultaneous rinsing of ten jugs.

The apparatus for filling and automatic weighing permits of filling ten jugs at once. A differential pulley, hooked to shears, supports a swing bar from which the cask to be emptied is suspended by chains.

A galvanized iron tube carries a funnel at its upper part and supports ten receptacles of the same capacity. The level of the oil is kept constant in the funnel by means of a glass tube that communicates with the bung hole through a rubber tube. The air can enter the cask, and consequently allow the liquid to flow, only when the level of the oil in the funnel exposes the lower orifice of the glass tube.

In order to fill the jugs, the lower cock being closed, the upper is opened. The oil fills the receptacle and rises in the small oblique glass tube, in which it takes the level of that contained in the funnel. The upper cock is then closed and the lower one is opened. The oil flows into the jug placed beneath, while the air enters through the small tube. It is scarcely necessary to say that the ten jugs are filled at the same time. A porcelain cylinder entering each receptacle through a stuffing box permits of regulating the apparatus once for all. The capacity of the receptacle is thus varied until the weight of the oil furnished is perfectly exact.

The level of the liquid in the funnel is not absolutely constant, but the diameter of the small glass tube is very feeble, so that in practice the variation in weight is never more than thirty grains.

These apparatus appear to be somewhat complicated at first sight, but they are, nevertheless, very simple and strong. A child can operate them, and the maneuvering of the cocks is learned in less than an hour.

The cuts show the arrangement of the apparatus and the method of using them in the oil works where they are in operation.—La Nature.

THE BLOT ACCUMULATOR.

THE accumulator shown in the accompanying cuts is the invention of Mr. G. R. Blot and is fairly well known in France. The plate which is used in this cell is made on the well known Planté principle, but it has achieved such excellent results in the laboratories of Mr. Preece and M. D'Arsonval, that the modifications introduced by Mr. Blot require some detailed explanation. It should also be mentioned that its reputation does not depend entirely on laboratory tests, for it has been used in actual work for a considerable period, and judging from the remarks of the users—who, not being electrical engineers, are unable to bestow upon them skilled attention—the cells seem to have given great satisfaction, in spite of the fact that they are called upon to work at rates of discharge much above the normal. We have recently expended considerable energy in endeavoring to demonstrate that durability is of vital importance—nay, is almost the determining factor—in one's estimation of a cell. How far the Blot accumulator will fit in with this desideratum remains to be seen, though in fairness it should be stated that trials extending to two years have been made on the plates with what are stated to be excellent results. The capacity per unit of weight, and the high rates of discharge of the Blot accumulator, are especially noteworthy, and these features, combined with the mechanical construction of the plate, ought to make the cell of special interest at the present moment. We would remark at the outset that we have not made any personal tests whatever on the Blot accumulator. Mr. Blot has allowed us to inspect correspondence and reports, and we have had an opportunity of examining the plate, but the figures that are mentioned in this article are entirely quoted from experiments made by others.

The plate is composed of a series of flat coils round the core, a, a, of which are wound, as shown in Fig. 1, two lead ribbons, D and C, half millimeter in thickness, one, D, being corrugated and embossed, the other, C, being corrugated only. The cores of the coils are of nonplastic metal, and are soldered to the frame, which also consists of lead, not liable to be attacked (Fig. 2). This ingenious arrangement gives a large active surface with a small amount of lead (0·333 m² per kg. of plate), as well as great porosity, due, we presume, to the layers of the ribbon being kept apart by the corrugations.

The coils of all sizes, which are formed as shown in Fig. 2, are sometimes cut into two equal parts along the straight line, a, b, and each part forms the coil. Fig. 3 shows the mounting of a plate composed of four coils, which constitute the ordinary type of plate. Figs. 4 and 4A show the smaller type. The solderings, S, Fig. 3, of non-plastic metal, keep the core of the coils on the frame, M, N, O, P; these solderings, which are also of unoxidizable metal, insure the electrical conductivity of all the leaden ribbons. It is claimed that these solderings of unoxidizable metal do not undergo any alteration after prolonged action of the element. The arrangement of coils, shown in Figs. 3 and 4, in the frame of unoxidizable metal, M, N, O, P, show that the plate is free to expand vertically and laterally; the ribbons can also increase freely in thickness and in length, without disturbing the construction of the frame. One of the important points of the accumulator is the ingenious arrangement used by M. Blot for suspending the plates in the vessels. The plates are suspended in the liquid by means of a double frame of hard lead, c, c (Fig. 5), kept at the required distance apart by two bars of lead in the form of a screw, fixed by bolts, b. The two frames, c, c, have at the bottom notches, e, in which two sheets of glass, v, can be placed on the edges of which the frames are hung by means of the notches, e, as shown in Fig. 5. The plates are separated from one another by glass tubes placed between two sheets of glass or porcelain, or any insulating material, resting on the frames of the coils. Fig. 6 shows the larger type of plate.

The construction of the accumulators is exceedingly simple and mechanical. Two plates of a No. 2 cell, having a total weight of 3 kg., give a surface of 1 square meter, and it is claimed that M. Blot easily obtains at the normal rate of discharge 10 ampere hours per kg., which can, without difficulty, attain to 19 ampere hours per kg. Experiments performed by D'Arsonval at the Central Laboratory of Electricity with the quarter plate element (of a weight of 1,515 g.) are summed up in the following table:

	I.	II.
Rate of discharge in amperes estimated per kg. of electrodes (+ and −)...	0·86	1·33
Capacity in ampere hours estimated per kg. of electrodes (+ and −).....	19·0	15·8

After these tests the element was short circuited, then recharged at the rate of 1 A per kg. It showed at the normal rate of discharge a capacity of 15 A h. per kg.

At the recent meeting of the Société Internationale des Electriciens, M. D'Arsonval described the results that he had observed personally for more than a year

FIG. 1.

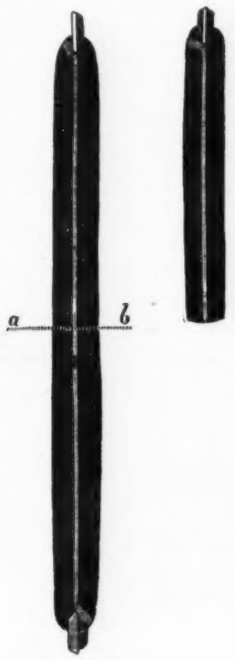


FIG. 2.

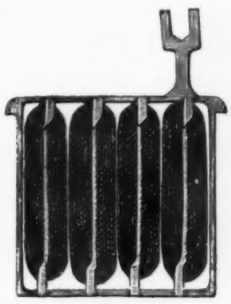


FIG. 4.

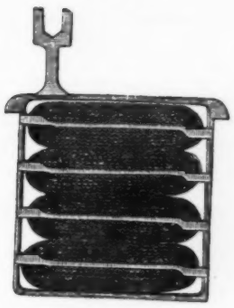


FIG. 4A.

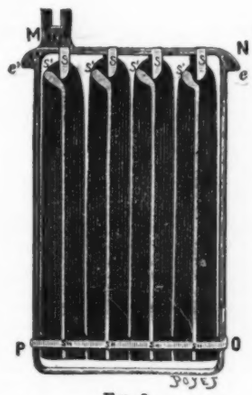


FIG. 3.

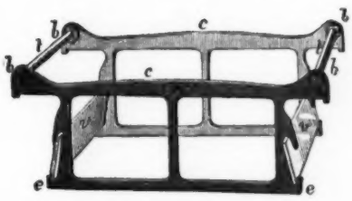
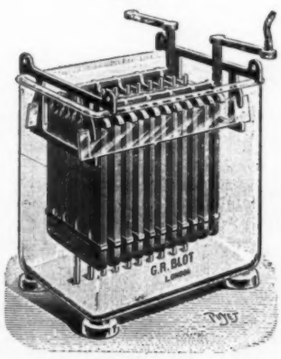


FIG. 5.



COMPLETE CELL.

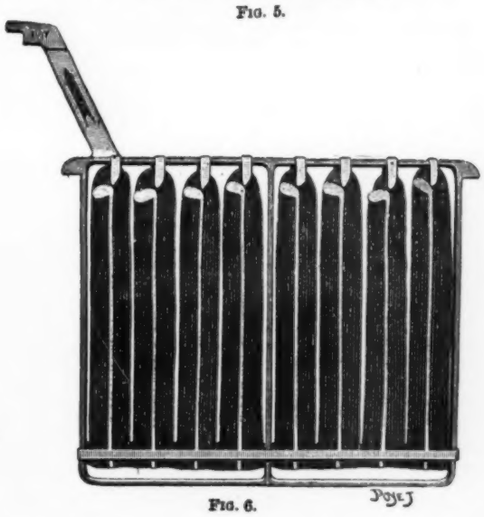


FIG. 6.

with a battery of 14 elements. To confirm his remarks, he quoted the assertion made by Mr. Preece when describing a great number of experiments made at the General Post Office from February 28, 1895, to January 4 last. Mr. Preece had subjected the accumulators sent to him to most rigorous tests. For instance, he had put them on short circuit for 10 minutes at an output of 200 amperes, until the electromotive force fell, so to speak, to zero. He then left them for 12 days to recharge them afterward at the rate of 1 ampere per kg. He then obtained an efficiency of 79·2 in capacity and 64·8 in energy. The plates were then taken out, washed and dried; there was no precipitate at the bottom of the vessels, and all the plates were in perfect condition.

Mr. Preece gave some curves in support of his assertions, and showed that after a short circuiting of 5 minutes, with an output of 300 amperes, he obtained an efficiency of 80 per cent. in capacity and 67 per cent. in energy. An efficiency of 88 per cent. in capacity and 76 per cent. in energy is obtained when discharging at 6 amperes per pound of plate.

From these different results M. D'Arsonval concluded that this accumulator is really suited to all services suddenly demanding high powers and great variations. M. D'Arsonval added that he charged his battery of Blot accumulators on July 14 before leaving Paris. On returning, on October 23, the battery had lost scarcely any part of its charge. On November 20 following, two of the elements left in the open air had become sulphated; the first time they were charged they regained their original capacity.

Finally, M. D'Arsonval short circuited them for 24 hours, without finding any sign of deterioration. Lastly, he adds that it is possible to reverse the polarity and use the elements to the last, without the negative plates undergoing any alteration. The following efficiencies were stated to have been obtained at a rate of discharge of:

	Per cent.
1 ampere per kilog., the efficiency was	89
2 " " " "	80
3 " " " "	68
5 " " " "	50
6 " " " "	45

We have taken the foregoing details from the report of the proceedings of the Société Internationale des Electriciens, which has recently appeared in our French contemporaries, but we are assured by M. Blot that much higher results than those set forth have been obtained.

It should be mentioned, however, that a battery of these cells has been in use in the shipbuilding yard of Messrs. Lobnitz & Company, of Renfrew, for over four months, and while the normal rated discharge is given as 25 amperes, they are called upon every day to discharge as high as 80 amperes and sometimes more than 100 amperes.

It is also claimed by M. Blot that the accumulator will give occasionally 15 amperes per pound of plate. There is not the slightest doubt that the figures claimed for this cell are very exceptional, and if they can be realized in practice and maintained for a reasonable period, one might be sanguine of the future of accumulators. The plates are formed electrically, and are stated to take at most a week to form. As we have already mentioned, the construction of the plates is of the most simple character, the winding of the lead ribbons on the cores being done by unskilled labor. The embossing and corrugating of the ribbon is done by special machines, which turn out long lengths in a very short time.—The Electrical Review.

[Continued from SUPPLEMENT, No. 1059, page 16928.]

MOTOR VEHICLE TESTS.

THE ENGINEERS SUBMIT THEIR REPORT OF THE TESTS MADE AT CHICAGO—VALUABLE DATA FOR MAKERS AND USERS ALIKE.

INTERNAL RESISTANCE.

TAKING up the question of internal resistance, we subdivide it as follows:

(a) Friction of axle.
(b) Friction of tire skidding.
(c) Lack of resilience of tires and other parts of the vehicle.
(d) Friction of mechanism in self-propelled vehicles.
(e) Friction of brakes when applied.

These elements have been made the subject of discussion resulting from the experiments made on the various vehicles submitted for test, and are more or less fully treated of in the tests and deductions presented elsewhere in this report.

PULL OF ASSUMED VEHICLE.

In the assumed vehicle we have a power developed at the rims of the driving wheels of 50 per cent. of three horse power or

$$\frac{33000 \times 3}{2} = 49{,}500 \text{ foot pounds per minute.}$$

At an assumed speed of 10 miles per hour, this would give a pull of

$$\frac{49500}{880} = 56{\cdot}3 \text{ pounds capable of being exerted.}$$

This is the pull actually given out at the rims of the driving wheels and is supplemental to the factor of energy expended in internal mechanism and wheel resistance of drivers. It has to overcome in addition to external resistance the resistance of the steering wheels and other elements of internal resistance not involved between the motor and the rims of the driving wheels. In the assumed vehicle, without going into delicate details, this would be, say

$$\frac{400 \times 10}{1000} = 4{\cdot}0 \text{ pounds.}$$

It may be here noted that an excessive "gather" of the wheels will produce a component lateral skidding action of the tires, which may produce quite a large resistance.

ROAD RESISTANCE.

Very little accurate data on road resistance is available, but its elements may be pointed out and deductions made showing how important a factor good roads are in the consideration of economical transportation, whether by means of the motor cycle or otherwise.

We subdivide, then, road resistance as follows:

(a) Adhesion of Roadbeds to Tires.—This is appreciated when moving through wet clay, and there are good reasons for believing that on certain pavements adhesion is quite a factor in resistance

(b) Distortion or Low Resilience of the Roadbed.—This constitutes a large factor of resistance to the propulsion of a vehicle, as a bad road may offer ten times the resistance to motion which a smooth one will.

In this connection it was expected to have obtained valuable data from observations made on the electric motocycles and the profile of the course as before mentioned, but as this was impossible, a reference to former experiments determining total traction of wheels on different characters of roads will indicate the relative resistance between different roadbeds.

TRACTION ON ROADS.

The following table is from Molesworth's Pocket Book:

Resistance in pounds per ton (2,240 pounds) on different roads, exclusive of gravity:

Stone tramway	20
Paved roads	33
Macadamized roads	44 to 67
Gravel	150
Soft, sandy and gravel ground	210

Presumably these determinations were made at low speed, so that the element of air resistance may be neglected. The table shows a pull of nine pounds per 1,000 on a stone tramway, which corresponds fairly well to the surface on which our wheel determinations were made. Undoubtedly the axles were of the ordinary type and the tires of steel; thus in this case the resistance was almost wholly that of axle friction and lack of resilience, and corresponds to results under "wheel determinations."

On a macadamized road the pull as given by the table averages 25 pounds per thousand. Thus the difference between this and 9 pounds, the result on the stone tramway, or 16 pounds per 1,000, gives the element of road resistance on such a roadbed. Country roads on the basis of this table would probably correspond to the higher figure given for macadamized roads; this is equivalent to 30 pounds per 1,000. Deducting the stone tramway result, we have $30 - 9 = 21$ as an approximation to the resistance per 1,000 pounds of load which may be expected on common roads.

The assumed vehicle thus would have a constant road resistance to overcome, in addition to other resistances, of

$$\frac{1600 \times 21}{1000} = \text{about } 34 \text{ pounds}$$

were it fitted with steel tires and ordinary axles. But, as will be seen in the following section (c), the use of pneumatic tires on the rough road might readily reduce this resistance considerably, say to 20 pounds.

ADVANTAGE OF PNEUMATIC TIRES.

(c) Climbing Over Minor Obstructions on a Hard Road.—This constitutes resistance which, while of short duration in individual cases, becomes an element of considerable importance if such obstructions are frequent. Thus a discussion of this action will make clear the advantage of the pneumatic tire.

Supposing we have a wheel with a steel tire of 24 inches radius, and it encounters a stone 1 inch in height, then it is evident, unless the stone is crushed or pressed into the tire or roadbed, the load on the wheel will have to be raised over the stone. By a simple calculation it will be seen that this involves the momentary climbing of a gradient of 1 in 3½. In the case of the assumed vehicle with a load of 600 pounds on one driving wheel this would require a pull of

$$\frac{600}{3{\cdot}5} = 172 \text{ pounds.}$$

This increased momentary pull is overcome by the inertia of the vehicle in motion. To start with such stones in front of the wheels would require perhaps more static pull than the vehicle would be capable of exerting. This is well illustrated when, to prevent a vehicle running down hill, comparatively small obstructions placed in front of the wheels suffice to accomplish the result.

As the vehicle passes over such an obstruction the energy of position is given back partially in energy of motion, but as this is only accomplished by the action of gravity, the element of time is involved to such an extent that if the vehicle no sooner climbs one obstacle than it encounters another, energy is dissipated to a great extent. With a pneumatic tire such an obstacle would sink into the tire half an inch or more, and so reduce the momentary grade in proportion. Where a road is encountered having many such obstructions, the energy saved by the use of pneumatic tires will be considerable, as not only are the momentary gradients less, but energy is stored in the tire by its elasticity normal to the direction of pressure. This must not be confused with the results showing low resilience of a pneumatic tire under tangential pull.

RESISTANCE TO MOTION.

We may now sum the results as deduced from the consideration of the assumed vehicle, as follows:

Kinetic resistance—	Constant.	Incidental.
Acceleration	—	26·7
Max. grade, 5 per cent	—	80
Air	10	—
Internal resistance apart from that consumed between motors and drivers	4	—
Road resistance	20	100
Total	34	206·7

We found our assumed motor to be capable of exerting at a speed of 10 miles per hour a pull of 56·3 pounds at the rim of the driving wheels.

Part of the incidental resistance noted above may be expected during the progress of any trip of a vehicle, and if economy is considered, it may not be advisable to purchase pull at the expense of speed, but rather to design motors for the specific work they may be called upon to perform.

RESULTS FROM CONSOLATION RACE.

To illustrate this we might cite the run of the Mueller-Benz motocycle in the Times-Herald consolation race of November 2, 1895.

The distance traveled was 92 miles over comparatively light grades and ordinary roads, being from Jackson Park, Chicago, to Waukegan and return to Lincoln Park, Chicago. The net running time was 8 hours 44 minutes, and the gasolene consumed 31·59 pounds.

This indicates a speed of 927 feet per minute and a consumption of an average of one pound of gasolene required to run 15,450 feet.

In the tests shown above we found this machine at a speed of 984 feet per minute, and a pull of 73·4 pounds, developed 1,268,000 foot pounds of work at the rim of the driving wheels per pound of gasolene. Again, at a speed of 1,168 per minute and a pull of 34·7 pounds it developed only 588,000 foot pounds.

If the above economical development of energy were maintained, the average pull throughout the run would be

$$\frac{1268000}{15450} = 82 \text{ pounds.}$$

If, on the other hand, the latter development of energy be assumed, the average pull would be

$$\frac{588000}{15450} = 38 \text{ pounds.}$$

Undoubtedly something between these two possible developments of energy per pound of gasolene was given.

Within certain limits, therefore, it appears that, with the type of engine used in this machine, resistance to propulsion is not an important factor in economy of fuel, as with more work to be done the fuel develops higher duty. Whether this be an argument for or against the engine is a question treated in another part of this report.

ECONOMICS.

The economics of the motocycle is a broad subject, and it does not come within the province of this report to do more than touch on economy of consumption and use of gasolene as fuel.

A disregard of fuel consumption under the plea that gasolene is a cheap commodity must be considered unwarranted when it is realized that a capitalization of an extra amount expended for gasolene would justify a higher price to be paid for a vehicle more efficient in transferring the energy of the gasolene into propelling energy. An important factor in economy of fuel consumption is involved in control by changing the mixture of air and gasolene. It is evident that, given two vehicles possessing equal merits as regards their control, then the one accomplishing certain results with the least cost of operation represents a lower annual cost of operation than the other, and consequently a justifiable higher first cost. Aside from the actual cost of an increased amount of fuel, the disadvantages of handling or storing it is a matter for consideration, particularly if the more volatile petroleum products are used and the question of underwriters' restrictions is considered.

USE OF GASOLENE.

For the following notes bearing on the use of gasolene we are indebted to Samuel Rodman, Jr., explosive expert.

Gasolene is the lightest volatile product commonly obtained from the distillation of crude petroleum. Specific gravity, 0·660 to 0·690; boiling point, 158° F. to 194° F.

Naphtha is a lower product. Specific gravity, 0·690 to 0·700; boiling point, 175° F. to 230° F.

Benzene is a still lower product. Specific gravity, 0·730 to 0·760; boiling point, 248° F. to 302° F.

Petroleum, generally known as kerosene, is graded by flashing tests which run from 110° F. to 260° F. and over. Its specific gravity varies from about 0·82 to about 0·86.

All volatilize more or less readily, giving off hydrocarbon vapors, which, uniting with air, form explosive mixtures.

Careful investigations have been made with a view of regulating the storage and transportation of hydrocarbon oils. In the case of petroleum it has been determined that one volume of petroleum vapor renders 380 volumes of air explosive and 1,150 volumes inflammable. A red hot piece of metal or coal, or a spark from steel or flint will not ignite an explosive atmosphere of petroleum vapor, but white hot metal, flame or electric spark will readily do so. Naphtha exposed to an atmospheric pressure of 30 inches, at a temperature of 70° F., evaporates at the rate of about 0·09 pound per square foot per hour.

Many accidents are recorded from explosions of hydrocarbon vapors mixed with air. In the majority of those that have come under notice vapors of hydrocarbons have escaped into the air through some leak in the receptacle or pipe holding them, and explosion has occurred on the approach of a naked flame.

In closing this report we desire to acknowledge valuable services and assistance in conducting the tests as follows:

Our thanks are due to Messrs. Samuel Rodman and C. L. Brown for assistance at the tests and subsequently in figuring out results. For special wheels prepared for test we are indebted to the Hartford Rubber Company for those having pneumatic tires, to the Rubber Tire Wheel Company, of Springfield, O., for those having solid rubber tires, and to the Staver & Abbott Company, of Chicago, for those having steel tires. Through the courtesy of Mr. Frem. Messrs. Fairbanks, Morse & Company, of Chicago, furnished delicate scales for use in dynamometer work, and Mr. Ludlow, of the Crosby Steam Gage and Valve Company, furnished the speed indicators used.

L. L. SUMMERS, JOHN P. BARRETT,
JOHN LUNDIE, Chairman of Committee.
Engineers of Tests.

ENGINEERING NOTES.

The new Panama Canal Company is to be supplied with seven Lidgerwood cableways of the kind used on the Chicago Main Drainage Canal. The Panama cableways will have fixed towers and anchorages and the spans will be from 250 to 300 feet.

One of perhaps many little considered ways in which the forests of the country are being eaten is in supplying timber for railway trestle work. There are two thousand miles of trestle structure in the United States, according to an estimate by the Forestry Division. This trestle work has to be replaced entirely every nine years, on an average, and every year timber amounting to 260,000,000 feet, board measure, is used for this purpose. Nearly all the timber is cut from the largest and finest trees.

There has been recently launched at the famous Herreshoff's yard a small racing yacht, which has been dubbed the baby Defender, from her resemblance to last year's champion. She is a wooden boat, her keel frames, stem, stern post, deck beams, and carlines being of the best of oak. To the wooden keel is attached with Tobin bronze bolts a lead keel with a small defined bulge on each side, something after the plan of the leaden bulb of a finkeel boat, with a rake at the after end and slightly cut away forward, giving it a rounded form. The forward overhang has a rakish appearance and runs out into a small bow, the turn of the stern coming just above the water line in the same manner as that of the Defender. She shows little dead wood, as it is well cut away. Her principal dimensions are 33 feet 6 inches over all, 21 feet water line, 6 feet 9 inches beam and 6 feet draught.

The fortifications appropriation bill, as passed by the House, without division, makes specific appropriations amounting to $5,842,337, and in addition gives authority to the Secretary of War to make contracts involving the further expenditure of $5,542,276, under the Engineer and Ordnance departments, making a total expenditure authorized by the bill of $11,384,613. Of this amount $5,260,000 are appropriated and authorized by contract for gun and mortar batteries, and $5,502,873 for armament of fortifications. It is estimated that fifty-two 8 inch, sixty-three 10 inch, and forty-three 12 inch guns will be completed by June 30, 1897, at an expenditure, including the amount named, of $1,217,168. The bill contains a proviso that all materials purchased under it shall be of American manufacture, except when in the judgment of the Secretary of War it is to the manifest advantage of the government to purchase them abroad in limited quantities, which materials shall be admitted free of duty.

In melting pig iron in a cupola, how much of its silicon is burnt out? asks Mr. W. T. Keep, in the Foundry. Silicon, he replies, is not evenly diffused through either pig iron or castings; therefore it is not possible to obtain an analysis from drillings that will accurately give the silicon in either. The heat of the cupola, the rapidity of melting, the quality of the fuel, and many other conditions exert such an influence upon the silicon that the loss of silicon will vary. The making of gray iron castings, very fortunately, does not require an exact percentage of silicon. The lower the silicon in pig iron, the less the loss. Silvery irons containing 5 per cent. of silicon will impart most of their silicon to the mixture. Silicon iron with silicon over 7 per cent. costs more than that with lower silicon, and much more of the silicon is lost, and worse than that, the silicon will not be evenly diffused in the casting. Pig iron varies in composition so greatly from day to day that its exact composition cannot be determined. For this reason several irons should be used, so that a chance variation in one will not greatly influence the castings.

The new method of lining basic open hearth furnaces, now being introduced, possesses a special economical interest in that line and, according to Industries and Iron, is a simple operation. Mixed with the usual basic materials, in a dry state, is mineral pitch, bitumen, or other solid mineral or vegetable fusible hydrocarbon, so that the compound does not become plastic, but remains in a powdered condition. In lining a furnace, the latter is first heated to a high temperature, and the mixture of powdered basic material and pitch is then thrown into the furnace so as to be deposited where required; the pitch is immediately set on fire by the heat of the furnace, and serves to retain the basic mass in the spot to which it was directed when thrown into the furnace, whether the spot be on the bottom or walls of the furnace, the throwing in of the mixture being continued until the hearth has taken the desired shape and size. The heat of the furnace burns away all of the carbonaceous residue of the pitch, and the basic material is glazed or burned on in a solid mass, so that the furnace is provided with a substantially pure basic lining. The basic material preferred is dolomite previously burnt, and the pitch is the ordinary article.

In discussing the advantages of lubricating rails on curves the Railroad Gazette says that "Mr. W. Glanz, manager of the Halberstadt and Blankenburg Railroad, reports that ever since 1886 the lubrication of the inner side of the outer rails of curves has been practiced on his road. It was found necessary to use a quick drying material, which would not catch the dust, and thus serve to grind away rail and flange rather than to lubricate them. The company uses pure ground graphite mixed with water. It is applied with a long handled brush. The minute wet particles of graphite adhere sufficiently long to the side of the rail head, and have a surprisingly favorable effect in reducing curve resistance. The favorable effect of the lubrication is shown by a great reduction in the wear of wheel flanges and of rail heads. Before it was practiced, the tires had to be put into the wheel lathe every four or five months, but from the day the lubrication was begun their wear became less than on ordinary lines in level districts. They now require turning only once in eighteen months or two years; but this is partly due to the use of better steel. The cost of the lubrication has been insignificant. No increase in the number of track hands has been required. In the last year reported 1,355 lb. of graphite were used on the fifteen miles of curves. Altogether, the cost is estimated at about $1.80 per mile of curve per year."

ELECTRICAL NOTES.

At the annual meeting of the American Bell Telephone Company, held in Boston on March 31, says the Electrical World chairman pro tem. William H. Forbes, referring to the increase in capital stock, said it was necessary to meet the extension and increasing business of the company. The sale of 21,500 shares at $200 per share would yield about $4,300,000, and the necessities of the company during the coming year will just about absorb that amount of capital.

The Executive Committee of the Brooklyn Bridge Trustees is equipping sixteen of the cars with the electrical switching apparatus which was recently tested with excellent results. There will be four motors to each car, the cost per car being $3,645. The switching will be done fast enough to keep pace with trains running under a three-fourth minute headway; and each motor could in emergency run a four car train over the bridge on a headway of one minute.

The possibility within the near future of maintaining speeds of 100 miles an hour on electrically equipped trunk lines, and operating them with financial success, was admitted in a recent address by F. W. Webb, the chief engineer of the London and Northwestern Railway, England. Mr. Webb is, perhaps, the leading authority in that country on questions affecting the steam locomotive; and his three-cylindered compound will be remembered by visitors to the Chicago Exposition.

The Daily Chronicle, Eng., says that the Pacific Cable Conference, which is to meet at the Colonial Office, directly after the Easter recess, is looked forward to with the keenest interest in Canada and Australia. It is understood that definite tenders will be before the conference, and the chief business will therefore be to decide, not the feasibility of the cable or its cost, but the allocation of the costs between the colonies and the mother country, and whether it shall be a state cable or a company undertaking.

It was formerly supposed that disconnected or sliding joints were an absolute necessity to a good track if it was to preserve its alignment in all weathers. The success of the welded joint has disproved this idea; and, theoretically, it could have been shown that a steel track may be made continuous. Under the range of temperature to which it is ordinarily subjected, the maximum stress that will occur in a rigidly fixed continuous rail will be about 10,000 lb. to the square inch, which will be less than one-third of the elastic limit of the material.

An interesting and novel feature, says the Street Railway Journal, of the power station of the electric railway at Aix-la-Chapelle, Germany, is a rotary transformer with a capacity of 450 horse power, which provides the reserve for Sundays and holidays. It is composed of two dynamos connected on to one axle, the armature of one wound for 220 volts, which is the potential of the lighting circuit, the other 550 volts. Depending upon circumstances, each of the machines is able to serve as a motor and operate the other as a generator, so that the machine acts as a reserve for the two services.

It is stated that the Buffalo Railway Company, Buffalo, N. Y., has issued an order to all motormen and conductors requiring them to run cars at a slow rate of speed between the hours of 8:30 A. M. and 3 P. M. (on regular school days) in passing all public schools. The order also requires the speed to be reduced so as not to exceed six miles per hour 100 ft. before arriving at the school lot, and continue so until the school lot has been passed at least 100 ft. During the time that the children are assembling at school, while they are at play, or while they are leaving the school, the employes are instructed to take great care to prevent any accident.

Electric street car sprinklers are now running which are modeled on the lines of the regular street car. They are lined with zinc and will hold 2,000 gallons. The big brass arms which are to be seen on either side are controlled by a lever, so that they can be drawn back against the side of the car on the approach of a team. It is claimed for these cars that more territory can be sprinkled; that the work can be done more expeditiously and with a saving to any city that uses it, and that the cars attract no more attention than the ordinary electric car, and that the apparatus is so arranged that there is an economy in the use of water, the streets being only wetted sufficiently to lay the dust.

The Edison Electric Illuminating Company, of Brooklyn, on the night of March 25 held its annual reception and exhibition at its Pearl Street station. Prof. W. C. Peckham gave a practical illustration of making pictures with Roentgen rays, and showed several plates of objects, including a mouse. The animal's heart and kidneys were plainly visible. Other exhibits of interest were an automatic electric piano, the electric flower decorations, and the electric heating and cooking apparatus. In the electric cooking department were shown electric tea kettles, portable stoves, three-section broilers, coffee pots, hot water urns, curling iron heater and electric smoothing irons.

A very complete fire alarm equipment is to be placed in the warehouse of the Massachusetts Fireproof Storage and Warehouse Company, Boston. The testing and recording apparatus will be located in the office, together with an annunciator and a watchman's register placed in series with the doors. The thermostats will be placed in groups and connected to the 70-point annunciator in the office. A short circuit box will be placed on each of the seven floors. The arrangement will be such that the watchman, after 6 o'clock at night, cannot go out of the building without a record being made in the office. Should spontaneous combustion occur in any of the storerooms, it will be announced on the annunciator in the office. The watchman will then go to the floor on which the fire exists, and, as he passes through the doors, the opening of the doors will be announced in the office and the time registered. When the watchman returns to the office a test that anyone can make will prove whether or not he has closed the doors. An auxiliary test will show on which floor a door has been left open.

MISCELLANEOUS NOTES.

Dogs not being allowed in German railway carriages, Berlin owners of pet dogs have taken to using black leather hat boxes for their conveyance, the sides of which fall out on pressing a button, leaving the dog free when the guard has turned his back.

It is stated by a contemporary that it costs more to send a ton of goods from London to the west of Ireland than to Japan. A ton of woolen goods can be forwarded from London to New York for $4.80; to Chicago, a thousand miles inland, for $8.40, and to Japan for $12. The same goods sent from Derry to London cost $16.80, and from Gweedore, fifty miles inland, $28.80.

Of course there is no way of protecting plants or crops from injury when the temperature falls several degrees below the freezing point, but for light frosts the practice of burning any material that will form a dense smoke has been found useful in vineyards by forming a canopy over the field, which prevents the escape of heat by radiation from the ground.—Garden and Forest.

The carriages of a train running on the French Eastern Railway are now lighted by acetylene gas, for comparison with other illuminants. The train leaves Paris at 5:27 p. m. for Langny, and returns to Paris, where it stands for three hours at the terminus, for permitting of comparative observations by M. Dumont, engineer to the Eastern Company, and M. Chapron, of the P. L. M. Company. The results are said to be favorable to acetylene.

Capt. Balfour, of H. M. S. Penguin, reports three soundings of over 5,000 fathoms in the Pacific Ocean. Mr. V. Thorpe, surgeon of the Penguin, reports that a microscopic examination of the specimen from 5,147 fathoms shows that the remains of siliceous organisms are almost, if not entirely, absent. The mineral particles are in a minute state of disintegration, and consist of exceedingly fine flocculent matter, mixed with pumice and other glossy volcanic products, green crystals of augite and reddish crystals of pelagonite.

Glass bricks for all sorts of building purposes are now being manufactured by some Silesian glass works, and several distinct advantages are claimed for them. The bricks are made in various shapes, are transparent, so that they transmit light very freely, without it being possible, however, to see distinctly through them; they are very strong, and comparatively cheap, and lend themselves very well to the various building operations. They are specially suitable where universal light is wanted, in factories, conservatories, courtyards, arches, etc.

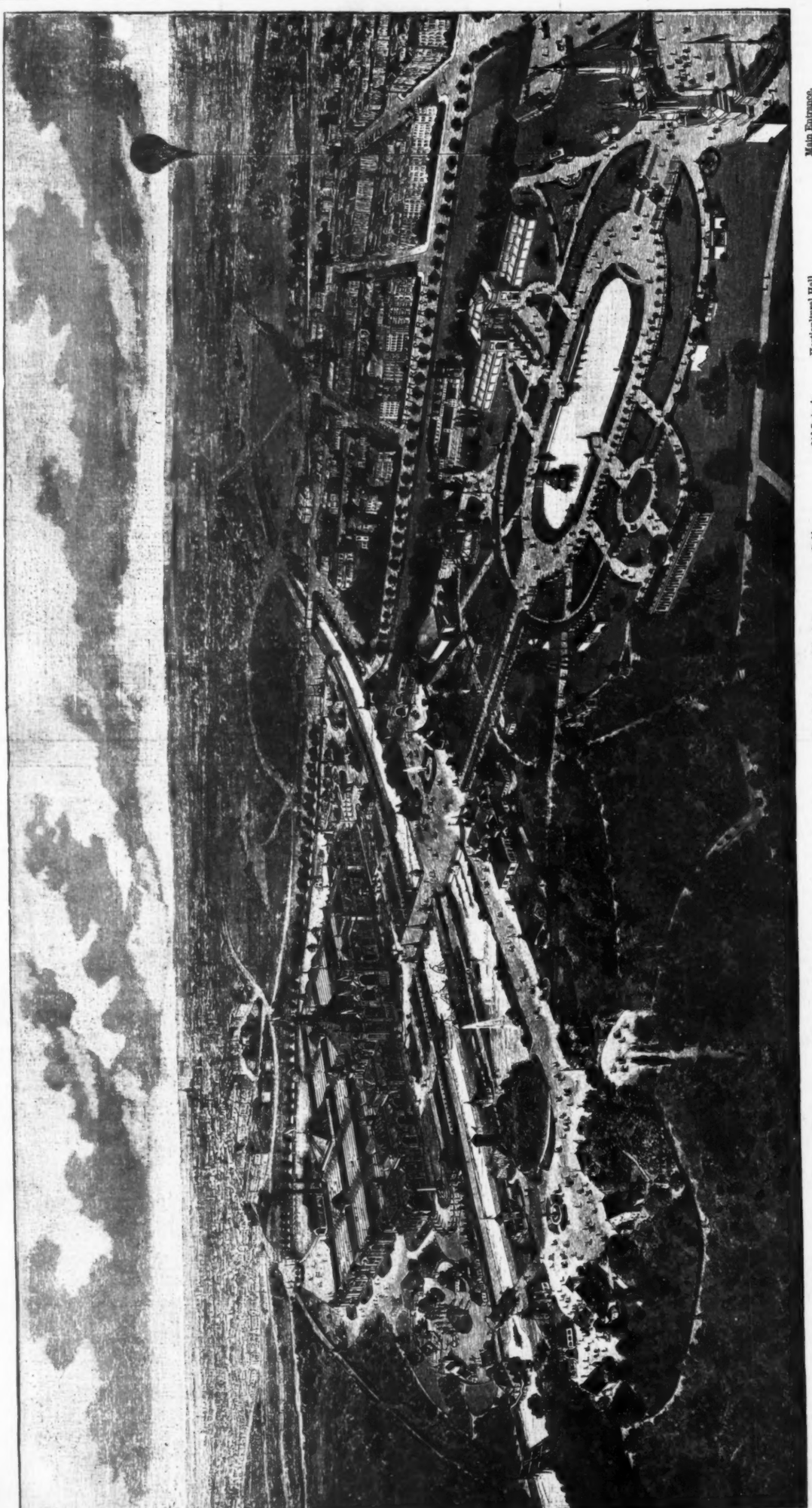
Southern California is experiencing a considerable oil boom. A number of oil wells developed recently in Santa Barbara and Los Angeles counties have proved profitable, and borings are being made in adjoining counties with satisfactory results. A new town, Oil City, sprang up in Fresno county a few weeks ago, and it is thought the region will prove very profitable. One somewhat unsatisfactory result has been the boring of many wells in the residence districts of Los Angeles, some of the wells being the most productive in the whole region.

According to an article in the Journal of the American Society of Naval Architects, the disadvantages of the use of oil fuel are: 1. The necessity for the erection of oil tanks and supply pipes at the coaling stations. 2. The loud noise occasioned by sprinklers. 3. The combustibility of oil. 4. The very small number of oils available as a fuel. 5. The present high cost as compared with coal. 6. Difficulty in overcoming the objectionable odor. 7. Destructive action upon plates and rivets. 8. The exceeding and intelligent care required to burn the fuel properly.

Paris artists have at last interfered with the daily sales of "pictures" at the Hotel Drouot. They are intended to sell the frames, the framemakers paying as little as 4 cents for the paintings, which are the common work of several men, one painting the sky, another the foreground, etc. So long as the sales were held only in Paris no one was deceived as to the character of the work, but the framemakers having extended their system to the country towns, the Société des Amis des Arts, believing that the public might be deceived, stepped in with the demand that the law forbidding the sale of new articles at auction be enforced.

The Prussian army enjoys the unenviable notoriety of having in Germany proportionately more cases of suicide than in any part of the empire, says the Broad Arrow. Statistics on this subject have lately been published in Berlin which show that, during the thirteen years from 1881 to 1893, no fewer than 105 327 persons in Germany terminated their own existence. The rate per head of the population varied from 46 per 100,000 inhabitants in the duchy of Saxe-Altenburg to 11½ per 100,000 inhabitants in Alsace-Lorraine. In the Prussian army, however, the rate per 100,000 men in 1893 reached the high figure of 65. The alarming percentage of suicides in the Prussian army seems to show in the case of a large number of men either a rooted dislike to soldiering or else the existence of a state of despair under a too rigid system of discipline.

The Australian starting machine, for starting horses on a race course, was tried at San Francisco a short time ago, and all the turfmen there declare that it was entirely successful and a great advance in racing methods. The machine consists of a light gate extending completely across the race track at the starting point. The gate is hung on a slanting wire on either side of the track, the wire stretching from a height of fifteen feet or more down to the track level, making an incline on which the gate is drawn upward and forward in front of the horses. The gate is operated by wire ropes and heavy weights. When the starter touches a button the gate springs upward and forward and the horses lined in front of it have a clear course. The jockey can urge his horse forward at the moment the signal to start is given, the gate getting well out of the way before the horses can bound forward at their first stride. From six to ten horses were sent off in perfect alignment and without a hitch of any sort.



BIRD'S EYE VIEW OF THE SAXON-THURINGIAN INDUSTRY AND TRADE EXPOSITION AT LEIPZIG, 1897.

THE SAXONY-THURINGIA INDUSTRIAL AND TRADE EXPOSITION AT LEIPZIG IN 1897.

IF some historian of the future should seek for an appropriate term to apply to the last quarter of our century, he could find nothing more fitting than "The Age of Expositions."

As Germany increased in strength, becoming a political power in the world, an impulse was given to her art, industry and trade. Then there were the great expositions in the first decade after the war which showed the German states, that were less advanced in the arts of peace than some other countries, how to attain a position that would command respect in those arts. As the importance of exhibitions as an educator and cultivator has been more and more realized their province has been extended, but in this decade they will certainly reach their limit.

The year that has just begun finds the north as well as the south of the Fatherland preparing for a great increase of its products, and, of course, the middle of the land cannot be left behind. The Saxony-Thuringia Industrial and Trade Exposition to be held in Leipzig in 1897 will offer it a welcome opportunity to gain a thorough knowledge of the development and possibilities of its industry and trade and to profit much by competition and comparison. The name given to the exhibition designates only the heart of the region that it will really cover, for the neighboring provinces and states, for instance, the Province of Saxony, the Duchy of Anhalt, northern Bavaria, western Silesia and the southern part of Mark Brandenburg, will be admitted.

As is well known, Leipzig is admirably situated for such an exhibition. It is central, has considerable outside trade, and is one of the first business cities of Germany. Besides this there are, near the city, grounds than which nothing more beautiful, practical and convenient could be imagined. Scarcely ten minutes from the City Hall, in constant communication with the railroad depots by means of convenient conveyances, is a tract of land—over 358,790 square yards—which combines perfect natural harmony with artistic decoration. From a glance at the accompanying engraving it will be seen that these grounds are well adapted for the use to which they are to be put next year.

The main entrance at the right is provided with a five gated portal, on both sides of which, in a half circle, are arranged little structures for ticket takers, guards, etc. Upon entering, a charming sight will meet the visitor. His eye will wander over the beautiful park, the bright beds, the green lawns and blooming shrubs, over the sparkling water in the great basin, along the broad main avenue, and rests finally on the cupola of the Industrial Palace, which is 148 feet high and towers above the tree tops. A number of large halls, pavilions and ornamental kiosks are scattered over the grounds, apparently without any studied arrangement, but one soon realizes that most careful consideration has been given to the placing of these structures. In the foreground we find the horticultural exhibition, the halls for garden produce and for flowers being arranged on opposite sides of the basin. Behind the former lies "Old Leipzig," a reproduction of "Auerbach's Hof" (tavern) and its immediate surroundings. Near by is the light structure of the Vienna Coffee House, and farther back an open theater, built after an antique model. Shady paths lead the wanderer along the main avenue to the beautiful Court of Honor with the King's Pavilion and the Pavilion of the City of Leipzig. Diagonally across is the hall devoted to the book trade. A splashing fountain in the center cools the Court of Honor. Water is not lacking in the landscape. Just beyond the Court of Honor there is a second very large basin, at one end of which is an artistic mound in which a blue grotto is hidden. At night a stream of light will rise from its summit and float over the main restaurant with a weird effect. Around the basin are grouped the halls for Forestry, Fishery, Women's Work and Education, and there is a refreshment hall embedded in the wood.

The Exposition grounds are divided by the broad canal. The arrangement of the front part of the grounds prepares the body and mind of the visitor, in a certain sense, for what is awaiting him when he has crossed the bridge and begun the study of the treasures in the Main Hall. This is a most imposing building, and certainly the contents deserve a fine structure. Here will be found all that the most industrious of the German states have to exhibit as the products of their land, their workshops and their factories. This building covers over 36,000 square yards and will be so arranged that it can be enlarged to cover about 48,000 square yards. Half of it will be used as a Hall of Industry and the rear part as Machinery Hall. The two will be connected by covered passages. Before the Main Building is a wide open place, the Prachthof. Two lines of columns lead to the buildings on the right and left of the bridge containing the rooms intended for the use of the post office, the press, the health department, and the Administration buildings. Up the canal there is a second bridge which will attract much attention. It is a copy of the old Saxon-Thuringian covered bridges. By passing over this bridge the visitor will reach a village picturesquely situated on the edge of the Nonnenholz.

From the engraving it will be seen that the Leipzig Exposition is an important undertaking, destined to show the home industries of the states concerned to all the world, for all will be invited and it is expected that many foreigners will visit it. This expectation seems quite justifiable, because in the year of the Exposition the Leipzig Fair will have a special celebration in memory of the granting of the fair privileges by Emperor Maximilian in 1497. These two things, the Exposition and the Fair Jubilee, promise Leipzig a great influx of visitors next year.

May the thousands of guests that the summer of 1897 will find within the walls of the old city carry away the conviction that the Saxony-Thuringia Exposition gives a really complete idea of the immense industrial interests of the states whose name it bears.—Illustrirte Zeitung.

BIRD'S EYE VIEW OF THE SAXON-THURINGIAN INDUSTRY AND TRADE EXPOSITION AT LEIPZIG, 1897.

THE DYNAMITE EXPLOSION AT JOHANNESBURG.

"ONE woe doth tread upon another's heels" might well have been the cry of the people of Johannesburg of late, for the early weeks of the present year will long be remembered in the Transvaal for the rapid sequence of their tragic events. The ferment caused by Dr. Jameson's disastrous expedition was still very far from allayed, and the railway accident was not yet

EXTRICATING THE DEAD AND WOUNDED.

PIT 200 FT. LONG, 80 FT. WIDE, AND 30 FT. DEEP MADE BY THE EXPLOSION.

A GENERAL VIEW OF THE EFFECTS OF THE EXPLOSION.

THE DYNAMITE EXPLOSION AT JOHANNESBURG.

a thing of the past, when, on February 19, there occurred the terrible dynamite explosion which counted the killed and wounded of its victems by hundreds and rendered thousands of the poorer inhabitants of Johannesburg homeless.

Vredendorp, the site of the disaster, is a poor and overcrowded suburb on the southwest of Johannesburg, lying between Eordburg and Braatfontein, and populated chiefly by Malays, Kaffirs, Chinamen, and the poorest class of Europeans. This suburb, which is very generally known in the district as "the Malay Camp," is one of the most squalid and unsanitary areas of human habitations to be found in the Transvaal, its occupants being too poor to build houses of any material more substantial than mud, old packing cases, and corrugated iron; while its low situation, among surrounding hills, makes it little better than a swamp in the wet season. In all probability, the escape of the principal part Johannesburg with comparatively little damage was due to the soft, marshy nature of the ground on which the explosion occurred. Even as it was, all glass in the central part of the town was shattered, and many solid buildings were thrown down. Vredendorp itself was completely wrecked, and is now but an expanse of ruins.

The explosion took place at about half past three on the afternoon of Ash Wednesday, February 19. A

number of railway trucks laden with fifty-five tons of dynamite, destined to be used for mining and other operations, were being unloaded on the Netherlands Railway, together with trucks bearing ninety cases of detonators. The latter had not in the first instance been sent with the train bearing the dynamite, but had arrived later, some delay having occurred in the unloading of the dynamite. The whole freight had been standing in the glare of the sun for three days, and the process of unloading had just begun when the explosion took place. The dynamite had been imported in bulk and made up at Pretoria, and was on the way to a magazine near the town.

Such was the force of the explosion that it rent the earth open for a space of two hundred feet in length and thirty feet in depth. Pieces of the railway metals were twisted up like bits of straw, and others were buried deep in the debris. As soon as the first panic was sufficiently allayed to allow the realization of what had happened, large bands of men and women of all classes set to work to help the police to aid the victims. Until far into the night the work of excavation was vigorously carried on, fresh cases of death or terrible injury being disclosed at every turn. Within the next few hours some fifty corpses were taken in to the buildings of the Wanderers' Athletic Club, temporarily transformed into a hospital and mortuary. The scene here was a horrible one. Mutilated trunks and scattered limbs were laid out for recognition, and severed portions that defied all identification were gathered up into sacks for burial. Hundreds of injured persons were taken to the hospital during the evening, and when the limits of the building could accommodate no more of the patients who arrived in interminable succession, an infirmary was hastily improvised at the Wanderers' Club. The club buildings have since been provided with every comfort for the patients, and the medical and nursing attendance has been admirably organized.

All distinctions of class or nationality in Johannesburg have been merged in sympathy for the sufferers. The work of rescue and provision for the destitute and wounded has been carried on with fine unanimity and energy; £104,000 was subscribed for the relief fund in three days, and the sum has since been generously increased.—We are indebted to the Illustrated London News for the engravings and particulars.

THERE are 2,287 foreign students this semester in German universities, out of a total number of 28,600. The foreign students are chiefly at Berlin, Leipsic, and Munich.

[ENGINEERING AND MINING JOURNAL.]

THE MINERAL AND METAL PRODUCTION OF THE UNITED STATES IN 1895.

THE total value of the mineral and metal production of the United States in 1895, as shown in the accompanying table, amounted to the enormous sum of $673,881,505, which compares with a similar total of $578,470,058 for 1894, showing a total increase of $95,411,447 for the year. Of the whole amount last year $240,615,120 represented the value of the metals; $433,266,385 that of the nonmetallic products, including $5,000,000 for various unspecified products.

From these totals, however, it is necessary to make some deductions for articles which have been necessarily duplicated in the table. Among these is the ore used in making pig iron; a large part of the lead used in making white lead; the zinc used in making zinc oxide; the coal in making coke; the antimony ore used in making the metal; the manganese ore employed in making spiegeleisen, which is included in pig iron, and some other articles of the kind. A careful estimate of the proper amount of these deductions would give about $45,000,000 in 1895, against $34,000,000 in 1894.

Making these deductions, we have a total net value for 1895 of $628,881,505, as against $544,470,058 for 1894, the increase amounting to $84,226,503, or 15·5 per cent.

In the table published herewith the figures are limited strictly to our domestic production. In the cases of gold, silver, copper and lead, the representation is an altogether inadequate one, for large quantities of those metals are obtained from foreign ores and base bullion smelted or refined here; therefore, in a supplementary table below is added a separate statement of this production.

The totals given are, of course, of values only, as it would be impossible to present a total of quantities made up of such varied products. In studying the table, however, it must be remembered that, to make the comparison a fair one, the quantities of the various articles produced should be considered. The year 1894 was one of extremely low prices, and while in some directions the recovery has not been as great as had been expected, in some important lines—principally in iron and copper—the level of prices in 1895 was much higher for a considerable portion of the year. The values, therefore, will naturally show a greater increase than the quantities.

The figures given show that the United States last year took the first rank as a producer, not only of the precious metals, but also of the most important of the useful metals, iron and copper, while in coal it is still second only to Great Britain, with the certainty that in a few years it will take the first place. That this degree of development has been reached in a comparatively short period makes it all the more extraordinary, even when we consider the wonderful resources of the country.

To sum up, we may say that our mineral industries made a notable advance during 1895, not only in the quantity of their production, but in the methods, and in many cases in the quality of the output. The figures given above show the very great importance of those industries to the prosperity of the country, and while the result for 1896 is still a little doubtful, we have every reason to believe that there will be at least no ground lost, and that this year will show a substantial gain over any previous one in our history. In our next issue we will take up in detail the metallurgical productions of the different metals.

(To be continued.)

MINERAL PRODUCTION OF THE UNITED STATES IN 1894–95.

Compiled for THE MINERAL INDUSTRY, Vol. IV.,

By Richard P. Rothwell, editor of the *Engineering and Mining Journal*.

No.	Products.	Customary Measures.	1894. Quantity. Customary Measures.	1894. Quantity. Metric Tons.	1894. Value at Place of Production.	1895. Quantity. Customary Measures.	1895. Quantity. Metric Tons.	1895. Value at Place of Production.
	NON-METALLIC.							
	Abrasives—							
1	Corundum and emery	Short tons	1,130	1,106	$100,500	385	349	$56,400
2	Garnet	Short tons	1,000	907	55,000	2,065	1,873	93,350
3	Grindstones	Short tons	29,989	27,200	257,596	36,389	33,004	290,378
4	Millstones	Short tons	297	269	4,447	105	95	8,525
5	Tripoli and infus. earth	Short tons	1,663	1,508	22,825	1,788	1,622	28,049
6	Whetstones	Short tons	1,735	1,574	84,430	1,609	1,459	78,303
7	Alum	Short tons	72,000	65,304	2,160,000	75,000	68,025	2,925,000
8	Antimony ore	Short tons	165	150	9,075	1,093	992	37,905
	Asbestos and talc—							
9	Asbestos	Short tons	263	240	4,350	1,010	916	11,400
10	Fibrous talc	Short tons	50,500	45,804	505,000	66,500	60,316	665,000
11	Talc and soapstone	Short tons	21,044	19,087	401,962	18,885	17,129	361,353
12	Asphalt	Short tons	4,198	4,080	75,654	14,300	12,970	300,000
13	Bituminous rock	Short tons	34,199	31,018	148,120	43,778	39,707	143,456
14	Barytes	Short tons	23,758	21,548	95,032	20,255	18,371	99,030
15	Bauxite	Long tons	10,732	10,908	42,928	14,145	14,371	56,580
16	Borax	Pounds	13,140,384	5,960	919,841	13,506,356	6,126	742,850
17	Bromine	Pounds	379,444	172	98,655	394,854	179	102,662
18	Cement, natural hydraulic	Bbls., 300 lbs.	7,813,766	1,064,297	4,455,928	7,694,053	1,047,006	4,597,285
19	Cement, Portland	Bbls., 400 lbs.	611,229	110,877	1,309,446	749,059	135,879	1,430,089
20	Clay, refractory	Short tons	3,375,798	3,061,794	4,050,985	3,750,000	3,401,220	4,500,000
21	Clay, kaolin	Short tons	34,552	32,346	185,169	30,910	28,035	258,431
22	Coal, anthracite	Short tons	a52,010,433	47,183,345	80,879,404	a58,362,985	52,965,539	89,048,699
23	Coal, bituminous	Short tons	a117,865,348	106,963,871	103,738,967	a138,079,466	125,347,053	125,480,488
24	Coke	Short tons	8,495,295	7,706,846	12,654,559	9,927,348	9,006,000	15,258,935
25	Cobalt oxide	Pounds	6,550	3	8,843	6,400	3	8,640
26	Copperas	Short tons	14,897	13,511	104,160	14,118	12,805	69,846
27	Copper sulphate	Pounds	b60,000,000	27,215	2,016,000	45,000,000	20,412	1,350,000
28	Chrome ore	Long tons	2,653	2,697	35,125			
29	Feldspar	Long tons	18,704	19,008	83,463	22,195	22,559	104,082
30	Fluorspar	Short tons	6,400	5,805	58,304	4,000	3,628	36,440
31	Graphite	Pounds	770,846	349	34,680	392,008	178	17,640
32	Graphite, amorphous	Short tons	165	150	1,253	1,100	998	4,700
33	Gypsum	Short tons	301,536	273,493	910,831	298,572	270,804	974,219
34	Iron ore	Long tons	11,880,000	12,070,080	30,790,000	16,950,000	17,221,200	29,662,500
35	Lime	Bbls., 300 lbs.	b66,750,000	5,148,320	28,575,000	b60,000,000	5,443,164	30,000,000
36	Magnesite	Short tons	1,370	1,243	7,964	2,200	1,995	14,700
37	Manganese ore	Long tons	11,735	11,924	74,890	14,883	15,121	92,044
38	Mica, ground	Pounds	829,500	377	35,957	750,000	340	31,956
39	Mica, sheet	Pounds	9,900	4	11,103	6,200	3	6,400
40	Mineral wool	Pounds	5,776	5,239	58,936	6,742	6,115	69,481
41	Monazite	Pounds	750,000	340	45,000	1,900,000	862	114,000
42	Natural gas				13,000,000			12,000,000
43	Paints, mineral	Short tons	47,593	43,167	1,011,182	47,084	42,705	1,096,767
44	Paints, vermilion	Short tons	91	83	111,309	118	107	118,190
45	Paints, white lead	Short tons	87,342	78,155	8,445,174	92,000	83,462	8,740,000
46	Paints, zinc oxide	Short tons	22,814	20,697	1,711,275	22,600	20,498	1,588,300
47	Petroleum (crude)	Bbls., 42 gals.	48,527,336	6,158,119	40,762,962	50,652,025	6,430,742	42,547,701
48	Phosphate rock	Long tons	952,155	967,485	2,856,465	831,498	844,802	2,577,643
49	Marls	Long tons	225,000	228,622	607,500	217,700	221,183	587,790
50	Precious stones				150,000			150,000
51	Pyrites	Long tons	107,462	109,192	466,466	81,000	82,296	353,560
52	Salt, evaporated	Bbls., 280 lbs.	11,708,659	1,498,193	5,586,326	12,521,498	1,539,178	5,844,348
53	Salt, rock	Bbls., 280 lbs.	2,341,922	297,376	784,053	1,367,638	173,602	518,740
54	Silica, sand and quartz	Long tons	477,670	485,313	418,612	523,640	532,018	553,138
55	Slate, roofing	Squares	611,776	180,474	2,007,321	645,361	190,377	2,062,239
56	Slate, other manufactures	Square feet	4,393,125	12,966	390,736	3,786,590	11,170	369,052
57	Stone, limestone (flux)	Long tons	3,544,398	3,601,459	2,126,636	3,890,000	3,444,240	2,542,500
58	Stone, marble	Cubic feet	6,331,379	518,532	3,576,853	6,942,533	568,593	4,086,261
59	Stone, onyx	Cubic feet	1,450	110	29,000	800	60	10,750
60	Sulphur	Long tons	441	448	7,056	12,000	12,192	192,000
61	Other building stones				b60,000,000			33,000,000
	Total non-metals				378,877,939			428,356,385
	METALS.							
62	Aluminum	Pounds	817,600	371	490,560	900,000	408	495,000
63	Antimony	Short tons	220	205	39,300	433	393	68,847
64	Copper	Pounds	358,504,314	160,392	33,540,480	386,453,850	175,294	36,944,988
65	Gold	Troy ounces	1,983,619	c59,824	39,761,305	2,265,612	c70,470	46,830,200
66	Iron, pig	Long tons	6,657,388	6,764,572	71,966,364	9,446,308	9,597,449	108,632,542
67	Lead, value at New York	Short tons	160,867	145,906	10,585,048	156,864	142,328	10,132,768
68	Quicksilver	Flasks, 76½ lbs	30,440	1,056	1,066,840	33,978	1,179	1,313,589
69	Silver, commercial value	Troy ounces	49,846,875	c1,550,387	31,403,531	46,331,295	c1,441,087	30,254,296
70	Zinc spelter	Short tons	74,004	67,135	5,309,882	81,858	74,345	5,942,890
	Total metals				194,092,119			240,615,120
	Est. products unspecified				5,500,000			5,000,000
	Grand total				578,470,058			673,881,505

(a) Bituminous coal includes brown coal and lignite. The anthracite production is the total for Pennsylvania, Arkansas, and Colorado. (b) Estimated. (c) Kilograms.

GEM FIELDS OF THE WORLD.

LITTLE was known of the ruby mines of Burma until England finally conquered the Burmese kingdom in 1888. This was accomplished by two expensive wars, and concessions for working the mines were exacted from the king as indemnity. Such was the idea of their richness, that when the Burma Ruby Mines Company, Limited, was organized in London, the spectacle was witnessed of white haired millionaires being clubbed away from a banker's office which they blocked in their eagerness to obtain a stock that was subscribed for three times over before the books were opened for the public, immediately selling for three times par. This stock, however, has not earned a dividend up to this day, and is quoted at less than 20 instead of 300. Last year the company's payment to the Indian government was reduced to encourage the enterprise, which has proved very unprofitable. The climate is the greatest enemy of the European. Of fifty English officers who visited the mines, forty-eight had the local fever; the other two had had it before.

The rubies, always associated with the ruby-red spinel, occur in a layer of sand and gravel in the valley bottoms, resulting from the breaking down of crystalline limestones, and are obtained by digging pits as deep as is practicable before they fill with water, and from open cuttings in the hill side; also from cavities and caves in the beds of granular limestone; rarely by quarrying into the rock. The limestone, the original matrix of the ruby, is identical with the rock in which opaque rubies and immense spinels are found, in Orange County, New York.

In Siam, the gem producing district lies in the interior, not very far from Bangkok. It produces many small, but good, rubies, sapphires, etc., and is worked by various persons and companies holding concessions from the government. The gems are found in a layer of soft yellowish sand, at a depth of from a few inches to twenty feet. The methods of working are of the most primitive Oriental kind.

In Macon County, N. C., in an alluvial deposit from the breaking down of crystalline rocks, some crystals of ruby have been found in flat, hexagonal tabular forms. A number of small gems have been cut from these, all of good color, and quite equal to the medium rubies from Burma.

The sapphire occurs associated with the ruby, in similar situations, and also is found where rubies have not been as yet. Ceylon furnishes many of the best, but they also occur, of fine quality, in Burma, Siam, and the Himalayas, and rarely in the Ural Mountains and the United States. In Ceylon the ruby, sapphire, spinel, alexandrite, cat's eye, and other gems are all found as rolled pebbles in gravel in or near old river beds in the government of Kandy.

Ratnapura, the city of rubies at the foot of Adam's Peak, at Ceylon, an altitude of 6,000 feet, is a great mining center. Pits are sunk to the depth permitted by the pumping appliances in search of gem bearing gravel, and when this bed is not reached within the limit of possible water clearance the pit is abandoned and trial made elsewhere. It seems as if, with the application of machinery adequate to keeping the pits clear of water, this constant abandonment of those sunk would no longer be necessary, and the profits known to have been made by native workers would be largely surpassed by the Europeans.

But the hopes entertained as to both Burma and Ceylon have been disappointed hitherto; nor does there appear any chance of future success, unless with some improved methods of machine working. One who has been active in this gem-mining enterprise says:

"What we want is an honest machine, one that will not only obtain for us the gemiferous stuff, but would securely guard it from the pickers and stealers until it can be raised to the surface and treated under European supervision."

This is impossible down in the pits of Ceylon, as no European could long endure their heat. As a result of the work undertaken by European mechanical agency in Ceylon the bazars of Colombo were fuller than had been ever known before of gems of various kinds; but few of these had passed through the hands of the companies working the mines.

Nearly all the fine sapphires of the past fifteen years are from a remarkable discovery made in 1882 in the Zenskar range of the Himalayas, in northwestern Kashmir, near the line of perpetual snow. A landslide removed an abundance of sapphires, which at first were used as gunflint by the natives. One writer speaks of having seen about a hundredweight of them in the possession of a single native. Traders, however, soon carried them to commercial centers, where their value became known. The Maharajah of Cashmere promptly sent a regiment of Sepoys to seize upon the mines and to harry the natives who were suspected of having stones in their possession or any knowledge of new localities where the gem could be found.

In our own country, corundum occurs at various places along the eastern flank of the Appalachian Mountains. At Franklin, Macon County, N. C., Col. C. W. Jenks first mined gem sapphires associated with corundum, and a number of blue, purple, and green stones, as well as rubies up to one carat, and of fine color, were taken out of the crystalline rocks of this region. On the Missouri River, on certain bars near

Helena, and elsewhere in Montana, sapphires occur in an auriferous glacial gravel resting on a slaty bedrock, where they have been found occasionally with mastodon bones as a by-product in gold mining since 1864.

A careful survey of one of the best of these, Eldorado Bar, led to the estimate that it would yield some 2,000 ounces of sapphires to the acre; but only a part of these may be of gem quality. The stones found embrace a great variety of light shades of red, yellow, blue and green. The latter color is quite pronounced, being rather a blue green than an emerald green.

Nearly all of them, when finely cut, have a marvelous metallic luster, very beautiful, and strikingly peculiar to these from this locality. Much money has been spent here in work, but no true red rubies or true blue sapphires have been found; the so-called rubies found here, if of any deep color, are generally pyrope garnets.

The finest turquoises and richest in color have been found, for centuries, in small veins in a clay slate near Nishapoor, near Meshed, Persia; but these mines, long so prolific, have been rudely worked, and are now almost exhausted. Many turquoises reach the market from Egypt; they are really obtained from Mt. Sinai. This variety, although generally dark blue when found, often changes in a short time to a milky green. Very lately, also, turquoises have been announced in New South Wales, Australia, but the yield thus far has been trifling and of a very inferior quality.

Santa Fé, New Mexico, is the principal source of supply, and so are the Buno Mountains, Grant County; the rocks here are yellow and gray quartzite sandstone with porphyry dikes; the sandstones are probably of carboniferous age, but so uplifted and metamorphosed that their sedimentary character is obscured.

Nearly every mine so far discovered was worked by the natives before the advent of the Spaniards. The Spaniards seized the turquoise mines at Los Cerillos when they conquered New Mexico, and forced great numbers of captive Indians to work them. But in 1680 a large part of the mountain fell in, crushing a number of miners. This accident was the immediate cause of an uprising of the Pueblos, which led to the expulsion of the Spaniards. The Pueblo Indians procured the turquoise by cracking the rock from the sides of the mine by throwing water on the walls after they had been heated by fires built against them. This process generally injured the color. But since 1890 improved methods have been successfully used. Recent explorations have disclosed old workings in all the mines of New Mexico and Arizona; fragments of pottery, stone hammers, and similar objects are found on the ground and are discovered within the long hidden chambers, as also in the similar case of the Arabian turquoise mines near Sinai.

Companies are now working mines near Los Cerillos and the Buno Mountains, New Mexico, and elsewhere in that region. Much of the product is pale in color; but a great quantity of fine turquoise of robin's egg blue, equal to the finest Persian stones, is obtained, and a single piece sold for $4,000 is reported. Many of these gems have gone to Europe, where their excellence is acknowledged; and the total American sales from 1890 to the beginning of 1894 were not less than $500,000. This has proved the most profitable gem mining in the United States.

The most productive emerald mines, affording the finest gems, are near Muzo, an Andean village, in the State of Boyaca, United States of Colombia, about eighty miles northwest of Bogota. These mines lie in a deep round valley, and were worked for many centuries before the advent of the Spaniards. They are now the property of the government, which rents them to a company. Emeralds from these mines the Spaniards brought from Peru and took to Spain, where they were sold within a short time to Farther India.

The mine itself is an excavation about 600 feet feet wide, at the base of an abrupt cliff of bituminous limestone. This company employs five or six overseers, and 300 to 400 native workmen, who are lodged and fed on the premises, and get 20 to 40 cents a day. The work is done simply by tearing off with crowbars fragments of the rock from the side of the mine, which is cut into narrow terraces, like a gigantic staircase, and throwing them into a trough at the bottom.

When a certain quantity has been tumbled down, a heavy rush of water from a reservoir is sent through, breaking up and carrying away all the light rock and disengaging the emerald crystals; these, being heavy, sink to the bottom of the sluices and are caught by the riffler. This is simply the operation of sluices, well known to placer miners for gold. The emeralds occur in cavities and among the loose black powder which fills many of the veins. The sluice boxes are watched very carefully; but, as elsewhere, a large proportion of the stones are stolen and surreptitiously sold by the workmen. All the emeralds saved are at once sent to Paris to be cut. The product is worth about $100,000 a year.

The most recent discovery of emeralds is at the Emmaville mines, in the northern part of New South Wales. The emeralds occur in a granite rock, and are generally crystallized out as implanted crystals. Although 40,000 carats of these stones have been found, they are generally very pale in color, and no really fine gems have been obtained.

Magnificent emeralds have come from the rich and varied gem deposits on the Siberian side of the Ural Mountains. For nearly two centuries the Urals have been noted for their remarkable productions of beryl, emerald, amethyst, topaz, both blue and sherry color; tourmaline, alexandrite, phenacite and other minerals and gems that for beauty and quantity have given this region a foremost place in the mineralogical collections of the world. The mines are mainly open excavations. They are worked only by peasants of the Ural Mountains when they are not busy in the fields, never by proper machinery, yet they are a source of revenue to the Russian crown. The emerald mines of Takowaja, near Ekatherinburg, were leased for many years to a company at an annual rental of 60,000 rubles, but have not been worked since 1850, when the company could not afford to pay the rental, and until some one pays it, emeralds will not be mined in Russia again. Many fine gems were found here, as well as the alexandrite and phenacite. The magnificent beryls of Russia were found about sixty miles north of here and in Siberia.

Emerald mining in the United States is of recent development; at Stony Point, in Alexander County, N. C., in 1880, beautiful light colored specimens were found, but not in profitable quantities or of good quality. They occur in a red, gravelly clay and in the gneissoid rock of the Blue Ridge; the former a decomposition of the latter. As crystals they are magnificent, but they have little gem value. All those obtained by the Emerald and Hiddenite Mining Company in a dozen years of working these mines have not exceeded $15,000 in value. Some fifty miles west of Stony Point, in Mitchell County, a new locality was discovered in 1894, but none of the material afforded gems.

Fine beryls occur at Stoneham, Me., and on Mount Antero, Col., at an altitude of 13,000 feet, and at a mica mine near New Milford, Conn., where $15,000 worth were found between 1886 and 1889.

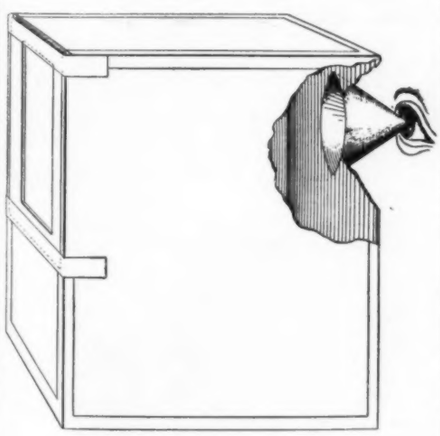
It is in granitic rocks that the finest yellow topaz is found, at Minas Geraes, Brazil, as well as the blue, green and white topazes in Perm, in the Ural, in Siberia, Japan, Madagascar, New Zealand, and in 1889 at Bald Mountain, near Chatham, N. H., in Colorado and Texas, and in igneous rocks in Colorado, Mexico, Australia, Straits Settlement, etc.

Garnet is a widely distributed gem occurring in many varieties in almost all mountain ranges composed of crystalline rocks, and under very diverse geological conditions. From the gold washings at Syssersk, in the Ural Mountains, come green garnets of high value, erroneously called olivine; while the Pegu mines in the Rangoon district of British Burma and Jeypur, India, furnish the purple almandines of great beauty in unlimited quantities. Ceylon produces the honey red essonite, which closely resembles the honey red spessartite of Amelia Court House, Va., that has recently been found as a byproduct in mining for mica. Wine colored garnets of value also come from the Tyrol, while at several American localities, especially along the Columbia River, large quantities of purple almandite have been found in the form of rolling pebbles. The finest red garnet, however, is the blood red pyrope, found in Bohemia, South America and the United States. In Bohemia nearly all the garnets are in an alluvium equivalent to our glacial deposits and associated with a variety of fossils; also with sapphire, zircon, etc. Such quantities of minute garnets remain in the sands that result from the operation of washing the soil and gravel that the sands are kept and sold for garden paths.—George F. Kunz, in New York Sun.

DIRECT VISION PICTURE FINDER.

By C. G. BUSCH.

THE device consists of a square straw board paper box, about six inches square, having a cone of pa-



A PICTURE FINDER.

per attached to the rear side, the aperture in the angle of the cone being about the size of the pupil of the eye. In the upper portion of the front of the box, directly opposite the cone, is a square aperture provided with grooves on the sides for the insertion or dropping in at the top of frames of straw board of different sizes, according to the size of picture to be taken, whether upright or horizontal.

In the illustration, a frame in an upright position is shown. The vision finder is used by being placed upon a hand camera supported on a tripod or other support.

By looking through the small aperture in the cone, one sees the extent of the picture to be taken or included by the lens, and is able, by comparing the edge of the front frame with the vertical lines of the view, to level the camera properly.

It is surprising how easily the view may be seen through the small aperture, right side up, and how readily the apparatus is constructed of such simple materials.

The focusing of the camera is done in the usual way, by means of a pointer moving over a scale marked off in feet, for different distances.

AMATEUR CLOUD PHOTOGRAPHY.*

THE blue color of the sky has as much action on an ordinary sensitive plate as the white color of light clouds (cirrus and cirro-cumulus); it is, therefore, necessary to diminish the action of the blue background of the sky. For this purpose a yellow screen is placed so as to intercept the rays; the light coming from the sky contains very few yellow and green rays, and is thus extinguished to a great extent; but, on the other hand, the great proportion of yellow and green rays which exists in the white light of the clouds passes the screen and makes an impression on the plate, if it has been made more sensitive to the action of yellow and green rays than the ordinary plates.

There are, therefore, three points to be considered: (1) the colored screen; (2) the sensitive plate; (3) the method of development of the images.

1. The Colored Screens.—Colored screens formed of films of gelatine or collodion must be rejected, because their tint changes very quickly in the light, and they easily lose their transparency. Either yellow glass must be used or cells containing a suitable liquid.

Yellow glasses make the most convenient screens of all; but the difficulty is to find suitable glasses which are always the same and of sufficiently graduated shade. Some are excellent, others not worth anything. Before recommending the use of colored glasses exclusively, some experiments ought to be made with the help of a glass maker, in order to ascertain what ought to be the exact composition of the glass, so that it may be reproduced with the exact tone at any time. It is unnecessary to add that the glass must be homogeneous and polished with quite parallel surfaces; only glass ought to be used which is colored in mass, and not white covered with a superficial layer of enamel.

The surest method, in case of not being able to get glass of which the composition is known, would be to use liquid screens, as I do. They are made with two parallel square glasses cemented together on three sides by square glass rods also with parallel sides, and with a thickness of six or seven millimeters, and length of side seven to eight centimeters, one side remaining open. If one does not wish to go to the trouble of making them, these cells can be obtained from instrument makers. Needless to say that before cementing, the glasses must be carefully cleaned with a solution of carbonate of soda, then with water, and lastly by being well rubbed with a piece of cotton wool dipped in alcohol: with these precautions, no air is to be feared along the sides of the cells. Before introducing the liquid, care must be taken to dip the open end of the cell in a bath of resin (a mixture of yellow wax and resin of equal parts). For ultimately closing the cell, it suffices to fasten on the edges, thus covered with resin, a little plate of glass cut to a suitable size, and which must be heated on a plate of copper to prevent its breaking. If found desirable, the aperture may be still more securely closed with sealing wax. Thus cells are obtained hermetically sealed, which can be used at every inclination without the liquid spilling and without air getting along the joints.

The easiest way of fixing these cells in position is to pierce a circular hole in the center of a flat piece of cork, the size of the sunshade of the lens of the camera. The plate is fitted into the sunshade and held by India rubber. The screen is thus in front of the lens, and it can be easily replaced by others more or less dark.

For the liquid, I have had to reject all solutions of organic colors, such as aurenthia, primuline, chrysoidine, for they alter in the light. The simplest one is to use the bichromate of potash. A saturated solution is prepared at ordinary temperature, to which is added, after straining, a few drops of hydrochloric acid. This saturated solution, introduced into one of the previously described cells, constitutes screen (1), which should be used when the clouds are very light, and the sky of a pale blue. A solution of half the strength forms screen (2), which may be used for well-lighted detached cirrus on a really blue sky; lastly, screen (3), consisting of one part of the saturated solution to three of water, should be reserved for very luminous clouds, as cumulus and cumulo-nimbus.

It is certainly more convenient and more simple to use colored glasses as screens; but while there is a doubt as to finding suitable glass, we can always be certain when using bichromate cells of straightway obtaining excellent screens, always precisely the same. The ones I possess have been in use two years, and no precautions have been taken to preserve them.

2. Sensitive Plates.—Special plates must be used for yellow light. The way of preparing these plates by means of ordinary plates is already well known; I did this at first. But I am certain that the necessity of preparing the plates is the principal obstacle which stops people taking photographs of clouds, who are really desirous of doing so. However, prepared plates are to be had in the trade, and they serve the purpose admirably.

Among the types of plates called orthochromatic or isochromatic, two have given me excellent results: Lumiere's orthochromatic plates, sensitive to yellow and green light, and Edward's orthochromatic plates.

There is, therefore, no necessity to prepare plates, as they are to be had ready made, and, at least in most cases, quite as good as those one could prepare personally. It has been said that the sensitiveness of these plates alters very soon, so much so that they are useless at the end of a few months. With regard to this, I can but quote the following fact. In February, 1893, I received from the firm of Lumiere three boxes of orthochromatic plates, of which the date of manufacture is unknown to me. These three boxes were simply placed in a cupboard of my bureau without any other precautions. The first box of twelve plates was used in the course of 1893; the second, only opened at the beginning of 1894, and used between the months of March and November; lastly, the third box was opened only in November, 1894, and the first two plates gave negatives which did not differ at all from those obtained from similar plates twenty months before.

Other similar boxes opened, then forgotten, for some months in a cupboard have always given me excellent results.

I intend to continue these studies; but it seems to me now established, that if the sensitiveness of these plates diminishes with time, this diminution is small enough to permit of the plates being used after more than eighteen months. Under these conditions nothing can be said against their use.

Focusing is done without any difficulty on a distant object; for instance, on a house in bright light. If the horizon is not far enough distant, an object can be taken comparatively near (at least twenty-five or thirty meters), then in order that the position shall

*By M. Angot, from Cosmos.

correspond with infinity, move the ground glass toward the lens a distance $\frac{f}{k-1}$, f being the focal distance of the lens, and k the number of times that the distance of the object which has been focused contains the focal length of the lens. For instance, if an object twenty meters distant has been focused with a lens, of which the focal length is twenty-five centimeters, then we get $k = \frac{2{,}000}{25} = 80$. In order that the clouds may be in focus, the ground glass must be brought a distance of $\frac{25}{79} = 0{\cdot}32$ cm., about 3 millimeters, nearer the lens. Of course the focus must be got with the colored screen, and the position thus found must be marked on the base of the camera, in order that the position of the frame may be known.

3. Development.—No mode of development must be rejected à priori · even developers called automatic, which can be bought ready prepared, and which have been very much run down, for they are by far the most convenient, and often give excellent results.

If the negative that we wish to develop contains only clouds of more or less the same intensity, the automatic developers may be used without any risk. I have used baths of hydroquinone, Lumiere's developer (of paramidophenol), etc., with success. It is advantageous to use baths which have already been used, and consequently containing a good proportion of bromide; a great contrast is then obtained between the clouds and sky, and the development can be carried further without fear of fogging.

If, on the contrary, the negative consists of clouds of very unequal luminous intensity, as for instance delicate cirrus and strongly lighted cumulus, the negative would not turn out well with automatic developers containing much bromide; the image of the cumulus would appear, and be over-developed before that of the cirrus had begun to show itself. In this case either a new bath must be used, very diluted, without bromide, and the development is then very slow, or else (which is preferable) use pyrogallic acid, in employing the method recommended by M. Londe. In this case the development must be commenced with a very small quantity pyrogallic acid, a little bromide, and relatively enough carbonate of soda, in such a way as to make all the parts of the image appear at first, without much intensity; then the necessary intensity will be obtained little by little, by the successive additions of pyrogallic acid. It is in this case only, where the intensity of the clouds is very different, that I think it advantageous to recommend progressive development instead of pyrogallic acid. In most ordinary cases, however, the automatic developers, which are more rapid, and more convenient to use, act very well.

In fact it is always as well to continue the development till the image is sufficiently dense, without intensifying, which is almost always possible. Negatives ought only very exceptionally to be intensified: to my mind, the intensification is always bad. It spoils the detail. A renewed or feeble negative is never worth as much as one that was made sufficiently dense in the first instance.

If I have gone into all these details, it is only to show that photography of clouds is a very easy operation, and within the reach of all amateurs. And let me just add, that with the darkest screen (saturated bichromate) and Prazmowski's lens, with a focus of 160 millimeters and diaphragm of $\frac{1}{10}$, I obtain negatives with a maximum exposure of six seconds for cirrus, with an ordinary amount of light with a Zeiss' object glass, a diaphragm of $\frac{1}{18}$ and very bright cirrus, having an exposure of $\frac{1}{15}$ of a second, has sometimes been more than sufficient, even too much.

It would be very interesting if amateurs in photography, so numerous at the present time, would try to photograph clouds which strike them as having interesting shapes, noting with care the hour when they were taken, and also the direction in which the clouds appeared.

NOTE.—American workers will find American isochromatic and orthochromatic plates, as well as the prepared metol and hydroquinone developers, answer equally as well as the plates and developers named. It is interesting to note that the bichromate cell is recommended as being the most reliable and is the same as has been adopted by the United States Weather Bureau in the photography of clouds.—EDS. SCIENTIFIC AMERICAN SUPPLEMENT.

ON THE ACTION OF THE X RAYS UPON THE DIAMOND.

By ABEL BUGUET and ALBERT GASCARD.

THE transparency of the different varieties of carbon and of its non-metallic compounds, established by Prof. Roentgen and then by the experimentalists who have studied the X rays, may serve to distinguish clearly the diamond from its imitations made of very opaque substances.

The proofs which we have the honor to submit to the academy show in juxtaposition silhouettes of genuine diamonds and of imitations, both loose and set. Prolonged exposure soon succeeds in causing the silhouettes of genuine diamonds to disappear, while false diamonds continue to behave like opaque substances. The same procedure has also allowed us to distinguish natural jet from its mineral imitation.

In addition to this graphic method, we have tried an optical method, in which we have tried the fluorescence studied by Prof. Roentgen. Diamond and jet, if interposed between the Crookes tube and a leaf of paper covered with a fluorescent substance (e. g., barium platino-cyanide), project upon the paper shadows lighter than those which appear beneath imitations placed near.

Here, then, we have two very certain tests: The graphic method leaves an irrefutable document, while the optical method is instantaneous. They will easily come into practical use, since a precious stone may be tested even in its setting, and without running any risk.—Comptes Rendus, cxxii, p. 457.

A SIMPLIFIED PHONOGRAPH.

THE phonograph, after remaining for many years an instrument "de luxe" of a price that placed it beyond reach, seems now to have become an object of diversion that may be easily procured. We recently described a new and very interesting model actuated by clockwork,* and now propose to make known another actuated by the same kind of mechanism. It perhaps does not reach all the perfection of details found in the apparatus just mentioned, but it marks a genuine progress over the small phonographs used in the talking doll and talking watch that have already been described in this journal.

The principle of this phonograph, which is due to Mr. Lioret, remains always the same. The impressed cylinders are made of celluloid and may be fixed upon a shaft set in motion by an ordinary clockwork that is wound up with a key. No. 2 of the accompanying Fig. 1 shows us the clockwork movement and the adjusted cylinder. Above, there is fixed a vibrating disk with rubber transmitters of a style already well known. The trumpet for loud voice auditions presents a few interesting peculiarities. It is shown in section in No. 1 of Fig. 1. The vibrating disk is a sheet of mica placed at the bottom. Upon this rests externally a metallic rod bent into the shape of a hook, and held by a screw placed in the interior of the trumpet. This arrangement assures a certain sensitiveness of the disk. The words are not always very distinct, but the airs of flourishes are remarkable. We have operated this interesting little phonograph on several occasions. Without attaining the perfection of details of the similar apparatus that we have hitherto made known, it constitutes a very simple and amusing toy that will be capable of captivating even grown people.

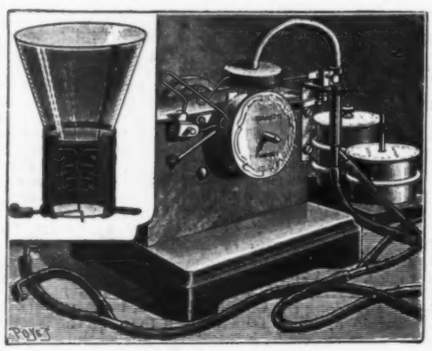


FIG. 1.—A SIMPLIFIED PHONOGRAPH.

1. Details of the vibrating disk. 2. General arrangement.

Fig. 2 shows another model of the phonograph still simpler than the first, and which constitutes the plaything that is now ready to be placed in the hands of children. The mechanism is the same as that described above, but the clockwork movement is simplified and is similar to that used in talking dolls. At the side is the celluloid cylinder, which may be easily changed at will. The vibrating disk is analogous to the one spoken of above. The trumpet placed above has a cylindrical form. The entire mechanism is inclosed in a box of very strong cardboard which has the great advantage of permitting of an easy carriage of the apparatus and of at the same time forming a sounding box. There is a cover at the top and a small door at the bottom for the easy replacing of the cylinders.

FIG. 2.—PHONOGRAPH FOR CHILDREN.

These two latest models of the phonograph certainly constitute up to the present the last expression of simplicity in an apparatus that has for a long time remained a high priced one.—La Nature.

A DISCOVERY of much interest has been made in Western Kansas. This was the specimen of an extinct species of bison, the skull having an expanse of nearly four feet. Embedded below the humerus of the skeleton was a small but perfectly formed arrow head. The bison has not yet been identified with certainty, says Science. The bison skeleton will shortly be mounted in the museum of the University of Kansas.

* SUPPLEMENT, No. 1048, p. 16728.

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